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# Regulatory Impact Analysis of Air Pollutant Emission Standards and Guidelines for Municipal Waste Combustors

(U.S.) Environmental Protection Agency, Research Triangle Park, NC

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Abstract: The Environmental Protection Agency (EPA), under the authority of Clean Air Act 111(b) and (d), proposes to regulate air pollutant emissions from new and existing municipal waste combustors (MWCs). MWC emissions cause, or contribute significantly to, air pollution that endangers public health and welfare. The Standards and Guidelines require the reduction of emissions to the air of organic compounds (principally dioxins and furans), metals (cadmium, mercury, chromium, lead, nickel, etc.), acid gases (sulfur dioxide, hydrogen chloride, etc.), nitrogen oxides, and carbon monoxide. The Standards identify these pollutants as MWC emissions and nitrogen oxides. MWC emissions consist of MWC organics, MWC metals, and MWC acid gases. MWC emissions is the designated pollutant that triggers application of 111(d); the Guidelines do not address nitrogen oxides. Currently, EPA new source review permitting directives to the states recommend control of most of these pollutants at new, large MWCs.

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# of
# Air Pollutant Emission Standards and Guidelines
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# Municipal Waste Combustors

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## A Description of the Economic Impacts of, and Regulatory Options for, Clean Air Act §111(b) New Source Performance Standards and §111(d) Existing Source Emission Guidelines

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October 1989

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# Regulatory Impact Analysis
# of
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# Standards and Guidelines
# for
# Municipal Waste Combustors

Prepared by
Office of Air Quality Planning and Standards
U.S. Environmental Protection Agency
Research Triangle Park, NC

October 1989

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# Executive Summary

The Environmental Protection Agency (EPA), under the authority of Clean Air Act §111(b) and (d), proposes to regulate air pollutant emissions from new and existing municipal waste combustors (MWCs). MWC emissions cause, or contribute significantly to, air pollution that endangers public health and welfare. EPA's intent is to require new and existing MWCs to control emissions to the level achievable by applying the best demonstrated system of continuous emission reductions, considering costs and environmental impacts. Under the proposed Guidelines, some requirements for existing MWCs are less than those for new MWCs, largely due to the extra expense of retrofitting, that is, installing, air pollution control devices at existing plants.

In this document the regulations for new sources are called Standards, and the regulations for existing sources are called Guidelines.[1] The Standards and Guidelines are parts of an overall approach to addressing the municipal solid waste (MSW) disposal crisis that confronts the nation. This approach is described in the recent EPA publication *The Solid Waste Dilemma: An Agenda for Action.*[14]

The Standards and Guidelines require the reduction of emissions to the air of organic compounds (principally dioxins and furans), metals (cadmium, mercury, chromium, lead, nickel, etc.), acid gases (sulfur dioxide, hydrogen chloride, etc.), nitrogen oxides, and carbon monoxide. The Standards identify these pollutants as "MWC emissions" and nitrogen oxides. MWC emissions consist of "MWC organics," "MWC metals," and "MWC acid gases." "MWC emissions" is the designated pollutant that triggers application of §111(d); the Guidelines do not address nitrogen oxides.

Currently, EPA new source review permitting directives to the states recommend control of most of these pollutants at *new, large* MWCs. New source performance standards that are already on the books have required control of particulate matter on many MWCs since 1970, but not control of the other pollutants.

Emission limits for large new MWCs (greater than 225 Mg per day capacity) and for very large existing MWCs (greater than 2,000 Mg per day capacity) are based on what is achievable with spray dryers followed by fabric filters, while those for small new MWCs and for existing MWCs with capacities in the 250 to 2,000 Mg per day range are based on dry sorbent injection followed by upgraded electrostatic precipitators. Emission limits for small existing MWCs (under 225 Mg per day capacity) are based on electrostatic precipitators without acid gas controls. Operational standards are included in both Standards and Guidelines to control organic emissions.

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[1] The Guidelines will not be regulations that are applied directly to existing MWCs. Instead, the Guidelines will be used by state agencies to develop state regulations that will be applied to existing MWCs.

The Standards and Guidelines both require the separation from MSW of potentially recyclable items to comprise about 25 percent by weight of the MSW received at each MWC. Separated items would not be combusted and therefore would not contribute to MWC emissions. The Standards and Guidelines also require MWC operator training.

The Standards will cost the nation in excess of $100 million annually, and the Guidelines, about $300 million annually. If the costs to individual MWCs were added to MWC tipping fees, the results, averaged across the county, would be 20-plus percent increases—from about $40 to $50 per Mg of MSW combusted at the MWC. These numbers are based on the selection of regulatory alternative IV for the Standards, and IIB′ for the Guidelines.

Many of the benefits have not been quantified. The absence of sufficient exposure-response and valuation information precludes a comprehensive benefits analysis at this time. However, some benefits for reduction of particulate matter and sulfur dioxide have been quantified. For the Standards, the partial benefits total $80 to $133 million annually, and for the Guidelines, $107 to $171 million annually.

**Chapters 7 through 13 of this regulatory impact analysis do not incorporate recent changes in the regulatory packages. Except where noted, the costs for control of $NO_X$ emissions from large new MWCs, for Guidelines regulatory alternative IIB′ (similar to IIB except that very large existing MWCs must have best particulate matter and acid gas controls and small existing MWCs need have no acid gas control), and for materials separation at both new and existing MWCs, are not included in the text and tables. A change in particulate matter emission requirements for existing MWCs also is not incorporated into the analysis. The economic analysis, including the analysis of the distribution of impacts, was conducted only on regulatory alternatives I, IIA, IIB, III, and IV, exclusive of these recent additions and changes.**

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# Units and Conversions

This report uses metric units, some of which may not be familiar to all readers. The following is a short guide to the units and their conversions.

## Conversions

| To Approximate | As | Multiply by | Examples from Text |
|---|---|---|---|
| Mg (megagram) | Ton (2,000 lb) | 1.1 | 225 Mg ≅ 250 tons<br>2,000 Mg ≅ 2,200 tons |
| mg/dscm (milligrams/dry standard cubic meter) | gr/dscf (grains/dry standard cubic foot) | $.44 \times 10^{-3}$ | 34 mg/dscm ≅.015 gr/dscf<br>69 mg/dscm ≅ .030 gr/dscf |
| TJ (terajoule) | $10^9$ Btu ($10^9$ British Thermal Units) | .95 | 820 TJ ≅ 780 x $10^9$ Btu |
| km (kilometer) | mile | 0.62 | 3.5 km ≅ 2.2 miles |
| C (°Celsius) | F (°Fahrenheit) | $9/5$, then add 32 | 230°C ≅ 450°F |

## Other Measures

| | | | |
|---|---|---|---|
| MWh | megawatt hour (3.6 GJ) | ppmv | parts per million by volume |
| ng | nanogram ($10^{-9}$ gram) | $\mu g$ | microgram ($10^{-6}$ gram) |
| $Nm^3$ | Normal cubic meter (A normal cubic meter is at 0°C, while a standard cubic meter is at 20°C; both are at one atmosphere of pressure.) | | |
| Opacity | A measure of the transparency of a smoke plume | | |
| $T = 10^{12}$ | tera = trillion | $M = 10^6$ | mega = million |
| $G = 10^9$ | giga = billion | $k = 10^3$ | kilo = thousand |

# Definitions

The following is a short guide to a selection of the abbreviations, acronyms, and terms used in this report.

## Economic Terms

| | |
|---|---|
| Annual Cost | Annualized capital plus annual operating costs |
| C/E | Cost effectiveness; the annual cost of emission control divided by annual emission reductions in megagrams, or by some other measure of effectiveness |
| National Enterprise Cost | The sum of the regulatory costs incurred by each MWC, discounted and annualized at rates reflecting estimated real market interest rates |
| National Social Cost | The sum of the regulatory costs incurred by each MWC, discounted and annualized at rates reflecting society's estimated real opportunity costs for capital and consumption |
| 1987 $ | Constant (real) dollars at their fourth quarter 1987 value |
| Per-Mg Costs | (A) The cost of combusting MSW, in $/Mg combusted, after subtracting revenue from the sale of electricity and steam; (B) the cost of an APCD in $/Mg combusted |
| Tipping Fee | The charge for incinerating MSW, usually $/Mg, imposed by MWCs on MSW collectors (Tipping fees may not reflect the full cost of incineration. They never include the cost of collecting and transporting MSW.) |

## General Acronyms

| | | | |
|---|---|---|---|
| APCD | Air pollution control device | MWC | Municipal waste combustor (a single combustor or all combustors at one site) |
| ESP | Electrostatic precipitator | | |
| FF | Fabric filter | | |
| FBC | Fluidized bed combustion | NIMBY | "Not in my backyard" |
| GCP | Good combustion practice | RDF | Refuse-derived fuel |
| MSW | Municipal solid waste | SD | Spray dryer |

## Regulatory and Legislative Terms

| | |
|---|---|
| Baseline | Conditions that would exist were there to be no new Clean Air Act §111(b) and (d) regulation of MWCs, and no relaxation of state regulations of MWCs |
| CAA | Clean Air Act |
| Guidelines | CAA §111(d) emission standards for existing sources |
| Model Plant | A hypothetical MWC plant representative of a class of plants; used to analyze impacts of regulatory alternatives |
| NSPSs (Standards) | CAA §111(b) new source performance standards, generally referred to in this document as "Standards" |
| RCRA | Resource Conservation and Recovery Act |
| Regulatory Alternatives | Sets of performance standards and related requirements for controlling emissions; used by EPA to help select the stringency of regulations |
| RFA | Regulatory Flexibility Act; also regulatory flexibility analysis, a study of the impact of regulations on small entities (businesses, governments, and organizations) |
| §111(b) | CAA section mandating emission standards (NSPSs) for new air pollutant emission sources |
| §111(d) | CAA section mandating emission standards (guidelines) for existing air pollutant emission sources |
| Subtitle C | RCRA subtitle governing hazardous waste landfills |
| Subtitle D | RCRA subtitle governing sanitary landfills |

## Pollutants

| | |
|---|---|
| CDD/CDF | Chlorodibenzo-*p*-dioxins and Chlorodibenzofurans |
| CO | Carbon monoxide |
| $CO_2$ | Carbon dioxide |
| HCl | Hydrogen chloride |
| HF | Hydrogen fluoride |
| $NO_X$ | Nitrogen oxides |
| PM | Particulate matter |
| $SO_2$ | Sulfur dioxide |

# Chapter 1

# Report Summary

**The following paragraphs contain a brief summary of each chapter in the remainder of this report.**

## Chapter 2: Background

Chapter 2 presents an overview of the legislative, regulatory, and policy background for the proposed Standards and Guidelines for municipal waste combustors (MWC) under §111 of the Clean Air Act (CAA).[1] In February 1989, EPA published *The Solid Waste Dilemma: An Agenda for Action*[14], describing a strategy for improving the nation's management of municipal solid waste (MSW) that involves minimizing the amount and toxicity of waste created and maximizing the amount of waste materials that are reused or recycled. The MWC Standards and Guidelines are a part of, and incorporate elements of, the *Agenda for Action.* They supercede the 1971 and 1986 new source performance standards for particulate matter (PM) emissions from MWCs. Under CAA §111(b) and (d), the Standards and Guidelines will affect both new and existing sources. CAA amendments being considered by Congress would require EPA to develop standards and guidelines similar in many ways to those now being proposed. The schedule for the proposed Standards and Guidelines is a result of a settlement agreement between EPA and NRDC *et al.* in litigation brought by NRDC to force EPA to promulgate regulations for MWCs. The Standards and Guidelines are just one part of the EPA regulatory initiatives affecting MSW management. They all will have varying impacts on the industry and on public and private decision makers who are concerned with MSW management.

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[1] See the definitions beginning on page xv for a quick reference to the many terms, abbreviations, and acronyms used in this report.

## Chapter 3: The Standards and Guidelines in Brief

Chapter 3 summarizes the proposed Standards and Guidelines. The Standards apply to new, modified, and reconstructed MWCs; the Guidelines apply to existing MWCs. The emission limits in the standards and guidelines are summarized in Table 3.1. In addition, there are requirements for good combustion practice (load levels, PM control device temperature, etc.), for operator training and certification, and for pre-combustion materials separation.

## Chapter 4: The Need for and Consequences of Regulatory Action

Chapter 4 discusses the reasons regulatory action is needed and the likely consequences if the requirements are met—and if they are not met. As MSW generation has increased over the years (about 170 million Mg[2] is expected for the year 2000), so has MSW combustion. In early 1987, 111 MWCs existed in the U.S., and over 200 were planned or under construction. While combustion is an attractive waste management option, it causes concern because of potential health and environmental threats from combustor emissions and ash. There is a need for Federal regulation of the emissions in that there is no market incentive for the industry to control its own emissions. Current instability in the market for recycled material inhibits full use of that option for disposing of MSW. State and local governments and the courts can not solve the problem. If there is compliance with the Standards and Guidelines, there will be improved allocation of resources in the MSW combustion market; air pollutant emissions will be reduced and air quality will improve; there will be increases in emission control costs; but energy consumption, water, and solid waste impacts will not be significant; there will be technological innovation; and state regulatory programs will be strengthened. Impacts on substitution, regionalization, industry growth, landfill utilization, the distribution of costs, and on Federal programs are not clear. If there is not compliance with the Standards and Guidelines, there will be more delays and controversy in the siting and permitting of new MWCs. Noncompliance will result in less emission reduction and fewer benefits than projected, as well as lower cost to the industry. Poor compliance would create the need to review the strategy and goals in *An Agenda for Action*, since the Standards and Guidelines are key elements of an overall nationwide MSW management plan.

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[2] Readers accustomed to English units of measure may wish to refer to the conversion factors given on page xiv for a guide to the metric units used in this report.

## Chapter 5: Control Techniques

Chapter 5 reviews the equipment and operating practices that are used to control air pollutant emissions from MWCs. Source reduction, materials separation, and recycling are practices that reduce emissions by reducing the quantity and/or toxicity of waste combusted. Good combustion practices include proper design, construction, and operation of an MWC. Operating conditions that are important are uniform waste feed rates, amount and distribution of combustion air, adequate combustion temperature and residence time, mixing, particulate matter carryover, downstream flue gas temperature, control, and combustion monitoring and control. It is also very important that the combustor operator be properly trained in how to minimize emissions through operation and maintenance of the combustor. Emissions are also reduced through the following technological means: cooling the flue gas to 230°C or below to minimize formation of MWC organics; use of electrostatic precipitators (ESPs) and fabric filters (FF) for PM and metals control; and use of dry sorbent injection and spray dryers for MWC acid gas control.

## Chapter 6: Regulatory Options

Chapter 6 presents the options EPA has for regulating emissions from MWCs. Relying on state and local action is not a viable substitute for EPA regulation; it would be fractionated, inefficient, and incomplete, and would be frustrating to industry segments located in different states with different requirements. Non-regulatory incentives to minimize waste and reduce emissions, including educational and research programs and economic incentives, are considered complements to, not replacements for the Standards and Guidelines. Regulation of the emissions as hazardous air pollutants under CAA §112 would not have allowed the site-specific consideration of appropriate control for MWCs. EPA selected the establishment of standards and guidelines under CAA §111 as the best means of reducing emissions from new and existing MWCs. Once this decision was made, EPA faced numerous secondary decisions, including selection of the pollutants to control, degree of control, and methods of enforcement.

## Chapter 7: Municipal Waste Combustor Characteristics and Control Costs

Chapter 7 describes the different types of MWCs and the costs to control their emissions. There are three principal types of MWCs: mass burn, modular, and refuse-derived fuel (RDF) combustors. A less common type is one that employs fluidized-bed combustion (FBC). Model plants for these MWC types are used to estimate control costs. The increase in capital costs for MWC's affected by the Standards and Guidelines will range from $1.1 million for one of the smaller MWCs to $19.7 million for large RDF MWCs. Total annual costs range from $.45 million to $5.4 million per plant. The percent increase in costs to combust each Mg of MSW ranges from 22 to 87 percent for the Standards (except for RDF MWCs, for which it is 67 to 275 percent), and from negligible to 520 percent for the Guidelines. (Percentage increases are over baseline capital and operating costs for the Standards, but only over operating costs for the Guidelines; hence, percentages for the Guidelines are somewhat exaggerated.) These numbers are based on the selection of regulatory alternative IV for the Standards, and IIB for the Guidelines.

## Chapter 8: Characteristics of the Municipal Waste Combustion Industry

Chapter 8 gives a brief industry profile—strictly from the economists' perspective—and the baseline projections of MWCs that will be operating or under construction by the end of 1994. The chapter looks at who and what organizations *generate* MSW (and thereby "demand" its collection), who and what organizations supply *collection* services (and thereby "demand" disposal services), and who and what organizations supply *disposal* services, particularly those of MWCs. The unusual features of this market structure is that the MSW generators—primarily households—pay for disposal in ways (like taxes) that do not encourage them to reduce the amount generated, even when the cost of combustion goes up. The baseline projections of MWCs through the 5-year analysis period is complicated by the dynamic nature of the industry and the large number of regulatory actions in the pipeline. In the first five years the Standards will impact about 65 MWCs, and the Guidelines, about 180.

## Chapter 9: Economic Analysis Objectives and Methodology

Chapter 9 explains the objectives, special features, and methodology of the economic analysis of the Standards and Guidelines. Economic analyses in general tell us something about the affordability of regulations, whether regulations will be inflationary, whether they will be efficient in achieving their purposes, whether they will alter production technology or the types of goods consumers purchase, and whether some groups will be adversely affected out of proportion to their contribution to pollution. Economic analyses give EPA insight in how to draft regulations so that positive impacts will be maximized and negative impacts minimized. The analyses produce much of the input data needed for benefit analyses. The economic analysis for the Standards and Guidelines is unusual in that it encompasses simultaneous CAA §111(b) and (d) actions, and is concerned with impacts on an industry where ownership of the emission sources is split between public and private. The myriad assumptions, analytical conventions, and underlying calculations that form the basis for projecting the economic impacts are explained. The methodology of the analysis includes the usual tasks related to data collection, projection of future MWC utilization, and analysis of price increases. The unusual aspect of the methodology, however, is a procedure to see how the Standards and Guidelines may affect municipalities' selection of MSW disposal technology.

## Chapter 10: Economic Analysis Findings

Chapter 10 displays the economic analysis findings in several tables. If the increased costs of combusting each Mg of MSW are added to MWC tipping fees, the Standards and Guidelines will result in increases, averaging over 20 percent. The national social cost for the Standards will exceed \$100 million, and for the Guidelines, \$300 million.[3] Emission reductions are described. The analysis of substitution among combustion technologies and between combusting and landfilling suggests that some mass burn refactory wall MWCs now operating may close. It also indicates that the Standards and Guidelines will cause a little stretching out of construction schedules, forcing more MSW to be landfilled than might be the case in the absence of further regulation of MWCs. Sensitivity analyses of two parameters used in the economic analysis, namely the rates used for annualizing capital costs and the capacity utilization of MWCs, demonstrate that the economic findings reported in this regulatory impact analysis are reasonably on target.

## Chapter 11: The Distribution of Impacts (Regulatory Flexibility)

Chapter 11 focuses on possible adverse economic impacts to households, local governments, and small businesses, and how the standards and guidelines have been designed to mitigate those impacts. No MWC service area will experience severe household impacts from the regulation although smaller service areas may have slightly higher than average household impacts (still not severe). Likewise, no local government will be severely impacted. The Regulatory Flexibility Act (RFA) requires EPA to prepare a regulatory flexibility analysis if a proposed regulation will have (1) a significant economic impact on (2) a substantial number of small entities. The impacts will be significant, but only a minor number of small businesses and small governments have MWCs. Although a regulatory flexibility analysis is not required, EPA nevertheless has prepared this regulatory flexibility analysis and is making every effort to involve small entities in the regulatory development process and to ensure that the cost burden on small entities will not be out of proportion to the pollution they cause.

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[3] These figures do not include costs for control of $NO_X$ at large new MWCs, for best acid gas control at very large existing MWCs, and for materials separation at both new and existing MWCs.

## Chapter 12: Benefits

Chapter 12 presents benefit estimates associated with reduced pollutant emissions from MWCs. The estimated economic benefits reflect individuals' willingness to pay for cleaner air. Benefits are estimated for PM and $SO_2$ emissions. Added up for the nation, the annual benefits currently quantified come to $80 to $133 million for the Standards (regulatory alternative IV), and $107 to $171 million for the Guidelines (regulatory alternative IIB). However, many types of benefits, and benefits associated with reduction of other pollutants controlled by the regulation, can not be quantified at this time.

## Chapter 13: Weighing Some of the Benefits and Most of the Costs

The benefits analysis finds plenty of benefits, but is unable to quantify and add together enough to produce dollar sums adequate to serve as the *raison d'être* for the Standards and Guidelines. Benefit-cost analysis uses the principle that society is better off if potential net benefits (benefits minus costs) are positive and potential gainers are able to compensate potential losers. Unfortunately, data paucities preclude the application of this principle to the Standards and Guidelines at this time.

# Chapter 2

# Background

## 2.1 "An Agenda for Action"

Municipal solid waste (MSW) disposal problems are legion. MSW is overflowing our landfills and municipalities have embarked on a record-setting construction spree in pursuit of an incineration solution. Municipal waste combustors (MWCs) reduce the volume of MSW by 70 to 90 percent and the mass by about 75 percent. These combustors are a principal means for reducing our dependence on landfill space. But MWCs can pollute the air. In many locations current emission standards are inadequate to control the wide range of pollutants to the degree necessary to protect human health and welfare.

In response to the burgeoning MSW problem, EPA created a Municipal Solid Waste Task Force early in 1988 and directed it to fashion a strategy for improving the nation's management of MSW. The result is *The Solid Waste Dilemma: An Agenda for Action*[14], issued in February 1989. The *Agenda* calls for a systems approach to managing MSW, that is, the complementary use of source reduction, recycling, combustion, and landfills. The objective is to minimize the amount and toxicity of waste created by products we make and purchase, and to maximize the amount of waste materials that are reused or recycled. In short, EPA proposes to change the way we do business when it comes to waste generation and disposal.

EPA recommends integrated waste management at all levels of government for all categories of waste—municipal, infectious, sewer, industrial, construction and demolition, utility, hazardous, etc. For MSW, integrated waste management emphasizes a hierarchy of management methods. First and most important are source reduction measures. These decrease the volume and toxicity of *products*, and increase the useful life of *products*, in order to reduce the volume and toxicity of *waste*. Recycling, including composting, is next in the hierarchy. It will divert MSW from landfills and combustors, conserve energy, and slow the depletion of nonrenewable resources. At the bottom of the hierarchy are combusting and landfilling. EPA is preparing these Standards and Guidelines to decrease adverse health and welfare effects from combustion, and similar standards and guidelines to decrease adverse health and welfare effects from landfill gas. EPA also is revising design and operational criteria for landfills, and working on MWC ash management plans.

In short, the MWC Standards and Guidelines are a part of, and incorporate elements of, the *Agenda for Action*.

## 2.2 Project History

### 2.2.1 Existing Regulations and Guidance

In 1971 and 1986 EPA promulgated NSPSs for PM emissions from, among other sources, MWCs. The Standards and Guidelines will supersede these NSPSs insofar as they apply to MWCs. Neither addresses health concerns specific to the individual constituents of MWC emissions. To address some of these health concerns, and to establish better control over rapidly increasing numbers of new MWCs, EPA in 1987 issued operational guidance[1] to states for processing applications for the construction of new, large MWCs. This operational guidance is interim guidance that will terminate when these new §111 Standards are proposed in the *Federal Register*. The following are the regulations and guidance.

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[1] The terms "guidance" and "guidelines" have two distinctly different meanings. New source review operational *guidance* is a directive that has been issued by EPA to require the application of good combustion practice, spray dryers, and particulate matter control on all large new MWCs. The emission *Guidelines* will be used by states to develop plans to control existing MWCs.

**40 *CFR* Part 60 Subpart E** covers incinerators built after 1970 with a capacity to combust more than 45 Mg MSW per day. PM emissions are limited to 180 mg/dscm corrected to 12 percent $CO_2$.

**40 *CFR* Part 60 Subpart Db** covers industrial, commercial, and institutional steam generating units built after 1984 with a thermal input capacity greater than about 30 MW, which translates roughly to 225 Mg MSW combusted per day. PM emissions are limited to 41 mg/MJ, which translates roughly to 110 mg/dscm corrected to 12 percent $CO_2$.

**New Source Review Operational Guidance**[1] was issued by EPA in 1987 to guide state and local agencies in establishing permit conditions when processing new source review permits for new MWCs with a capacity to combust more than 225 Mg MSW per day. In general, the Guidance calls for emission control on these new large MWCs based on acid gas dry scrubbers followed by fabric filters or electrostatic precipitators, plus combustion controls. The Guidance is intended to control PM, metals, acid gases (HCl and $SO_2$), CO, and most organics. It applies only to new large MWCs and does not apply to new small MWCs or to any existing MWCs.

### 2.2.2 Report to Congress

Concern over emissions of chlorodibenzo-*p*-dioxins (CDD—often called simply "dioxins") led Congress in 1984 to direct EPA to study emissions from resource recovery facilities that burn MSW.[2] EPA broadened the study to cover emissions of air toxics,[3] including chlorodibenzofurans (CDF), and then to cover all emissions from all MWCs. In 1987, concurrent with publication of the results of the selection of a regulatory approach for MWCs, described below, EPA released a nine-volume report *Municipal Waste Combustion Study*[13]. This study represents the collection and organization of a growing body of technical data. It served as the starting point for development of the Standards and Guidelines.

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[2] The directive is contained in §102 of the Hazardous and Solid Waste Amendments to the Resource Conservation and Recovery Act (RCRA).

[3] The term "air toxics" describes all air pollutants that adversely affect human health and that are not controlled under CAA §108-110 and §112. Some states have lists of specific air toxics.

### 2.2.3 Regulatory Approach

In 1987 EPA published[8] an assessment of MWC emissions and a notice of intent to regulate these emissions under CAA §111. At that time the major question confronting EPA was whether to regulate MWC emissions under CAA §111 or §112. CAA §112, *National Emission Standards for Hazardous Air Pollutants*, mandates the imposition of emission controls on existing and new sources that emit certain pollutants found to be hazardous to public health. CAA §111, *Standards of Performance for New Stationary Sources*, mandates imposition of emission controls (new source performance standards or NSPSs) on new sources that emit pollutants not specifically listed as hazardous under §112, and mandates imposition of emission controls (guidelines) on existing sources whenever (1) such sources would be subject to an NSPS if the sources were new and (2) the pollutant of concern is not regulated under CAA §108-110 or §112. Regulatory development under §112 is more involved and time-consuming than it is under §111 because §112 requires rigorous documentation of health effects for the subject hazardous pollutant(s). The regulatory development process under §111 is different because §111 is not primarily focused on health effects, but more broadly focused on welfare, cost, and other effects of regulation, as well as on the health effects. EPA rejected §112 for use in controlling MWC emissions because the diverse health effects of the MWC pollutants are too small, for some pollutants, or too uncertain, for other pollutants, to justify a §112 regulation, and because §112 cannot be used to regulate some of the pollutants of concern, particularly lead and HCl. Regulation under §111 is now proceeding under a schedule EPA published along with the notice of options selection.

Although §111 does not place upon EPA the burden of justifying regulations solely on health grounds, Executive Order 12291 does require some examination of the health benefits of the regulation. This is discussed further in Section 2.6.

### 2.2.4 Litigation

On August 5, 1986, the Natural Resources Defense Council (NRDC) and the States of New York, Rhode Island, and Connecticut petitioned the Administrator of EPA to regulate air emissions from MWCs under CAA

§111 and §112 (New York *et al.* v. EPA [D.C.Circuit Nos. 87-1463 and 87-1466]). As stated in Section 2.2.3, in 1987 EPA published an advance notice of proposed rulemaking under CAA §111(b) and (d) but not §112. Then, in mid-1989, EPA and the petitioners in New York *et al.* v. EPA agreed to stay the proceedings in that action pending the Administrator's signature of the proposal by November 30, 1989, and signature of the final rule by December 31, 1990. That is the schedule EPA currently is following for the MWC rulemaking.

## 2.3 The Nature of CAA §111

Section 2.2.3 above is a brief sketch of why EPA elected to apply CAA §111 to control MWC air emissions. A grasp of §111 is essential to understand how EPA has structured regulation under §111, and why the regulation is split into two components—the Standards and the Guidelines.[4]

CAA §111 *Standards of Performance for New Stationary Sources* directs EPA to require polluters either to meet emission performance standards, or to follow design, equipment, work practice, or operational standards that will accomplish the same objective. The polluters of concern are non-transportation related activities that individually or collectively emit enough pollution to contribute significantly to ambient air pollution problems. These polluters are termed "stationary sources" and they range in size from oil refineries and power plants on the one hand, to dry cleaners and homes with wood-burning stoves on the other. Once on the books, §111 regulations generally are delegated to the states for enforcement.

Most §111 regulations apply to sources that are constructed after the regulations are proposed by EPA. These regulations are the NSPSs, which EPA prepares under §111(b). Over time some states adapt and apply the emission requirements of NSPSs to existing sources. This latter process may be accelerated by §111(d), which directs EPA to adapt certain NSPSs to the special problems of existing sources and to issue guidelines to the states on how states should enforce the regulations for existing sources. For MWCs, the NSPSs are termed "Standards" in this report, and the guidelines are termed "Guidelines."

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[4] In addition to the Standards and Guidelines, EPA is pursuing separately another regulatory action applicable to MWC air emissions. It relates only to emission test methods, and is not discussed in this regulatory impact analysis.

CAA §111(b) can be used only for pollutants that EPA has not listed as hazardous under §112. (Currently there are eight hazardous pollutants, another ten that EPA intends to list as hazardous, and many others that are under study.) Often, as will be the case with the Standards and Guidelines, a §111 regulation directed at sources of nonhazardous pollutants will, as a side effect, also serve to control one or more hazardous pollutants. If a nonhazardous pollutant to be controlled with §111(b) NSPSs is *not* one for which EPA has issued a national ambient air quality standard under §108-110, the pollutant is called a "designated" pollutant. A designated pollutant invokes §111(d) and EPA issues §111(d) guidelines. The net effect of designating a pollutant is to use §111 for the control of new *and* existing sources. There is no requirement that standards for new sources be the same as those for existing sources. Indeed, in the case of the Standards and Guidelines, they are different.

Except for certain situations not related to MWCs, §111 requires EPA to issue *performance* standards. A performance standard is an emission limitation or reduction

> . . . achievable through application of the best technological system of continuous emission reduction which (taking into consideration the cost of achieving such emission reduction, any nonair quality health and environmental impact and energy requirements) the Administrator determines has been adequately demonstrated.

*Only* when performance standards are infeasible may EPA promulgate design, equipment, work practice, or operational standards. §111 further provides for the replacement of design, equipment, work practice, and operational standards as soon as performance standards become feasible, and in certain other situations. While the Standards and Guidelines are predominantly performance standards, they have work practice and operational components.

CAA §111 regulations are subject to automatic review by EPA every four years.

## 2.4 Pending Legislation

A number of legislative actions that would affect municipal waste combustion are being considered by Congress. The Congressional Office of Technology Assessment (OTA) has summarized these potential actions in *Facing America's Trash: What Next for Municipal Solid Waste?*, Interim Summary, June 1989.[7] The OTA presents the options that Congress might consider in addressing the various facets of MSW management issues.

Also in June 1989, a Senate bill (S. 1113) was introduced to amend the Solid Waste Disposal Act (a forerunner of the Resource Conservation and Recovery Act—RCRA). It includes provisions that would create CAA §129 "Municipal Waste Combustion." This new section would require EPA to promulgate, within 18 months of enactment of S. 1113, NSPSs that would apply to new and modified MWCs and MWCs beginning operation after July 1, 1989 (unless they were substantially completed before that date). The pollutants to be regulated and the levels of the emission limits and other requirements that should be included in the NSPSs are specified in the bill. Existing MWCs would be required to comply with the NSPS within time schedules established by EPA but in no event later than four years after promulgation of the NSPS.

## 2.5 Regulatory Initiatives Affecting MSW Management

New regulatory initiatives affecting MSW management are being developed by EPA. The principal ones are described below. They all affect to one degree or another the economics of MWCs, and all will complement the Standards and Guidelines.

**Revised RCRA Subtitle D Criteria.** RCRA Subtitle D governs the landfilling of nonhazardous wastes. Revised regulations were proposed in August 1988; final promulgation is expected in December 1989. The revised regulations affect the siting of MSW landfills and also require that new landfills be designed with liners, leachate collection systems, and final covers to protect ground water.

**Toxicity Characteristic Expansion and Modification of Lead MCL.** Modification of the lead MCL (maximum contaminant level) was proposed in August 1988; final promulgation is expected early in 1990. The Toxicity Characteristic expansion was proposed in June 1986, and promulgation is expected in 1989. These two rules will affect the classification of solid wastes as hazardous or nonhazardous. They may result in classifying lower concentrations of toxic substances, such as MWC ash, as hazardous, thereby potentially increasing the amount of MWC ash that will have to be disposed of under the more stringent Subtitle C of RCRA.

**Superfund Municipal Settlement Policy.** An interim policy is expected in late summer 1989. The policy focuses on the issue of how municipalities that are potentially responsible parties at Superfund sites should be handled in the Superfund settlement process.

**Municipal Solid Waste Landfill Air Emissions Regulations.** With proposal planned for summer 1990, these will take the same form as the MWC Standards and Guidelines, and will complement the RCRA Subtitle D criteria. The standards may require a regulated landfill to install a gas collection system that routes the gas to a control device capable of achieving a 98 percent reduction in non-methane organics.

**Municipal Waste Combustion Ash Disposal Regulations.** The timetable is uncertain. For MWC ash disposal, the draft regulation includes the following requirements for MSW landfills: (1) double liners with leachate collection systems above and between them; (2) ground-water monitoring; (3) development of criteria and testing procedures for identifying characteristics of ash that may pose a threat to human health and the environment; and (4) closure requirements, post-closure care, corrective action, and financial assurance for these activities.[5]

The initiatives and some of their potential impacts are summarized in Table 2.1.

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[5] For more discussion of MWC ash issues, see Section 7.1.2.

**Table 2.1**: Impacts of Regulatory Initiatives in the MSW Area

| Initiative | Impacts |
|---|---|
| Revised Subtitle D Criteria | Increased cost may induce a small shift away from MSW landfills to MWCs, source reduction, and recycling. Will increase cost of MSW landfills (ground-water monitoring, liner systems, leachate collection systems, covers, potential corrective actions). |
| Toxicity Characteristic Expansion | Regulation of some MWC ash as hazardous may encourage shift to source reduction, recycling, and MSW landfilling. Will increase MSW landfill costs if leachate and gas condensate exhibit high toxic characteristics. Will increase MWC costs if ash exhibits toxic characteristics. |
| Superfund Municipal Settlement Policy | May encourage shift to MWC, source reduction, and recycling to avoid liability. May increase costs of MSW landfills. |
| MSW Landfill Air Emissions Regulations | May encourage shift from MSW landfills to other technologies. Will increase MSW landfill cost by requiring gas collection and control systems. |
| MWC Ash Disposal Regulations | May increase MWC costs. Overall impact difficult to predict. |

## 2.6 Executive Order 12291

The President issued Executive Order 12291 in February 1981.[16] It requires EPA to prepare regulatory impact analyses (RIAs) on all "major" regulations. An RIA describes the benefits and costs of proposed regulations and explores alternative regulatory and non-regulatory approaches to accomplishing the desired objectives.[11,15] A "major" regulation is one that, among other things, may have an annual effect on the economy of $100 million or more, and/or may result in a significant increase in prices. The Standards and Guidelines each may have social costs to the nation in excess of $100 million yearly, and each may result in significant increases in tipping fees in a few local areas. Thus, EPA considers the Standards and Guidelines to be major regulations and is issuing this RIA to explain the myriad facts, figures, analyses, and considerations that have gone into regulatory development.

In addition to asking for an analysis of benefits and costs, the Executive Order specifies that EPA, to the extent permitted (in this case) by the Clean Air Act and court orders, demonstrate (1) that the benefits of the Standards and Guidelines will outweigh the costs and (2) that net benefits will be maximized. Chapter 12 describes the benefits. As explained in that chapter, EPA cannot quantify some of the benefits at this time. Consequently, EPA cannot demonstrate *quantitatively* that the benefits of the Standards and Guidelines will outweigh the costs. Notwithstanding this quantification problem, EPA has determined that CAA §111 requires issuance of the Standards and Guidelines at the level of stringency described in the next chapter. For more elaboration on this point, see Chapter 13 and the *Federal Register* preambles[6] to the Standards and Guidelines.

## 2.7 Guide to the References

Most of this regulatory impact analysis report is a summary of research reports, analyses, correspondence, minutes of meetings and hearings, policy directives, legal notices, laws, regulations, and other documents relating to the development of CAA §111 regulations for MWCs. The principal references are listed in the Bibliography at the end of this report. Consult these references, as well as the preambles that accompany proposal of the Standards and Guidelines in the *Federal Register*, for more detailed information on the Standards and Guidelines. All references are held in public dockets and are available for inspection and copying during normal business hours. Contact:

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[6] These preambles will accompany proposal of the Standards and Guidelines in the *Federal Register* later this year.

Air Docket (LE-131)
Room M-1500,
Waterside Mall
401 M Street, S.W.
Washington, D.C. 20460

Hours: 8:30 a.m. to noon, 1:30 to 3:30 p.m.
Phone (202) 382-7549
Refer to Docket A-89-08

# Chapter 3

# The Standards and Guidelines in Brief

## 3.1 Applicability

### 3.1.1 Standards

The Standards as proposed would apply to MWCs for which construction, modification, or reconstruction commences after the date of proposal. An MWC is defined as a combustion facility used for burning MSW. MSW is refuse, more than 50 percent of which is waste consisting of a mixture of paper, wood, yard wastes, food wastes, plastics, leather, rubber, and other combustible materials, and noncombustible materials such as glass, metal, and rock. It includes household wastes as well as waste from institutional, commercial, governmental, and some industrial sources, but does not include industrial process wastes, or infectious hospital or medical wastes. MSW also includes refuse-derived fuel (RDF), which is solid waste that is shredded, classified by size, and/or processed (by removing the noncombustibles such as glass and metal) before combustion.

The Standards categorize new MWCs as large (located at plants with an aggregate capacity to burn more than 225 Mg MSW per day) or small (all others). The aggregate capacity of all new, modified, and reconstructed MWCs at one plant site is used to define MWC plant capacity. New MWCs will be subject to the requirements for the size category of the plant they are in. Units that commenced construction prior to proposal of the Standards are considered to be existing MWCs and will not be included in measuring aggregate capacity at a site for the Standards (but their aggregate capacity is used to determine applicability of the Guidelines).[1] Within the first five years, the Standards are expected to apply to about 150 individual MWC units located at about 65 different sites.

### 3.1.2 Guidelines

The Guidelines will be used by states to develop regulations to apply to existing MWCs that commenced construction prior to the date of proposal. They are classified as very large (located at plants with the capacity to burn more than 2,000 Mg MSW per day)[2] or large (aggregate capacity to burn between 225 and 2,000 Mg MSW per day) or small (all others). The aggregate capacity of all existing MWCs at one site is used to define MWC plant capacity. Individual combustor units will be subject to the requirements for the size category of the plant they are in. The Guidelines will apply to about 450 individual MWC units located at about 180 different MWC plants.

## 3.2 Emission Limits and Other Requirements

### 3.2.1 Standards

The Standards will limit emissions of a number of pollutants. See Table 3.1. Most are what is termed "MWC emissions." Constituents are categorized into three subclasses: MWC organics (including dioxins), MWC metals (trace metals that are condensable on particulate matter), and MWC acid gases (principally $SO_2$ and HCl). (The composite pollutant "MWC emissions" also is designated for regulation under the Guidelines.)

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[1] In this regulatory impact analysis, "MWC" means *both* a single combustor *and* all combustors comprising one plant site. Where the distinction is important, as it is here in defining large and small MWCs, it is made.

[2] Only regulatory alternative IIB′ of the Guidelines distinguishes between very large and large MWCs.

**Table 3.1**: Summary of Emission Levels in Standards and Guidelines[a]

| Pollutant | **Standards**<br>New MWCs | **Guidelines**<br>Existing MWCs |
|---|---|---|
| MWC Organics | **CDD/CDF:**<br>10 $ng/Nm^3$ (large)<br>75 $ng/Nm^3$ (small[b])<br>250 $ng/Nm^3$ (RDF[b]) | **CDD/CDF:**<br>10 $ng/Nm^3$ (very large)<br>125 $ng/Nm^3$ (others[c])<br>250 $ng/Nm^3$ (RDF[c]) |
| MWC Metals | **PM:** 34 mg/dscm<br>10 percent opacity | **PM:** 34 mg/dscm (very large)<br>69 mg/dscm (others)<br>10 percent opacity (all) |
| MWC Acid Gases | **HCl:** 25 ppmv or 95 percent reduction (large)<br>25 ppmv or 80 percent reduction (small) | **HCl:** 25 ppmv or 95 percent reduction (very large)<br>25 ppmv or 50 percent reduction (large)<br>None (small) |
| | **$SO_2$:** 30 ppmv or 85 percent reduction (large)<br>30 ppmv or 50 percent reduction (small) | **$SO_2$:** 30 ppmv or 85 percent reduction (very large)<br>30 ppmv or 50 percent reduction (large)<br>None (small) |
| $NO_X$ | 150 ppmv and mercury limit of 300 $\mu g$/dscm (large) | None |
| CO | 50 to 150 ppmv<br>(depending on type of MWC) | 50 to 150 ppmv<br>(depending on type of MWC) |

[a] See the definitions beginning on page xv for a quick reference to the many terms and abbreviations used here. This table summarizes *only* emission levels and does *not* cover requirements relating to good combustion practices, operator training, and materials separation.

[b] Small RDF MWCs (capacities less than 225 Mg/day) are allowed 250 $ng/Nm^3$.

[c] "Other" RDF MWCs (capacities less that 2,000 Mg/day) are allowed 250 $ng/Nm^3$.

The Standards will establish emission limits to address the three subclasses of pollutants, and operating standards to minimize formation of MWC organics. The Standards also will control nitrogen oxides ($NO_X$).

The following paragraphs summarize the emission limits and other requirements of the Standards.

### 3.2.1.1 MWC Organics

A dioxin and furan (CDD/CDF) emission limit of 10 ng/Nm$^3$ at 7 percent $O_2$ will be required at large MWCs, and 75 ng/Nm$^3$ at small MWCs, except that small RDF MWCs will have a limit of 250 ng/Nm$^3$. These limits apply to total tetra through octa CDD/CDF.

### 3.2.1.2 MWC Metals

All MWCs will have to limit emissions of particulate matter (PM) to 34 mg/dscm at 7 percent $O_2$. This PM limit will ensure good control of metals and is a more practical approach than setting individual limits for every metal. Also required is a 10 percent opacity limit (6-minute average, measured continuously).[3]

### 3.2.1.3 MWC Acid Gases

Large MWCs will be required to reduce HCl emissions either by 95 percent or to a level not to exceed 25 ppmv, measured during a compliance test and annual performance tests. Small MWCs will have to achieve either an 80 percent reduction or a 25 ppmv HCl emission level.

Large MWCs will be required to reduce $SO_2$ emissions by 85 percent or to a level of 30 ppmv on a daily block[4] 24-hour average basis, measured continuously. Small MWCs will have to achieve either a 50 percent reduction or a 30 ppmv $SO_2$ emission level.

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[3] A 10 percent opacity limit requires a smoke plume to be relatively transparent—in this case so that there is no more than a 10 percent reduction of light intensity when a beam of light traverses the center of a plume close to the top of a stack.

[4] When concentrations are averaged over time, block or rolling averages may be used. For block averages, the time interval and beginning and ending times are defined ahead

### 3.2.1.4 Good Combustion Practice

Good combustion practice (GCP) in this case involves operating an MWC within certain limits to ensure that MWC organics emissions are minimized on a continuous basis. The operating parameters include CO emission limits, combustor load levels, and flue gas temperatures.

CO emission limits will vary by type of MWC.[5] The limit will be 50 ppmv for modular MWCs; 100 ppmv for mass burn waterwall, mass burn refactory wall, and fluidized bed MWCs; and 150 ppmv for all other technologies.

MWCs will not be allowed to operate above 100 percent of maximum rated capacity on a 1-hour average basis, as demonstrated during a compliance test.

To minimize CDD/CDF formation and vaporization of metals, the Standards will require all MWCs to maintain a flue gas temperature of 230°C or less, on a 4-hour block average, at the PM control device inlet.

### 3.2.1.5 ASME Certification and Operator Training

As a part of GCP, the Standards will require certification of the MWC shift supervisor and chief facility operator by the American Society of Mechanical Engineers (ASME). Also, each MWC owner or operator will be required to develop a site-specific training manual to be reviewed with all employees associated with the operation of the MWC. The manual and training must be updated annually.

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of time, such as for 24-hour midnight-to-midnight averages; for rolling averages the time interval and period of next calculation are defined ahead of time, such as for 30-day rolling averages recalculated daily.

[5] See Chapter 7 for a description of the types of MWCs.

### 3.2.1.6 Materials Separation

The Standards will require all MWCs to prepare, have approved, and follow a plan for materials separation. The separation may be on-site mechanical separation, on-site manual sorting, a community materials separation program, or any combination of these procedures. MWCs must demonstrate removal of one or more of the following materials: paper, paperboard, metals (including appliances), glass, plastics, and household batteries. On an annual average weight basis, these removed materials must comprise at least 25 percent of the total MSW received at the MWC. (No credit will be allowed for yard waste in excess of 10 percent of the total MSW received.) An MWC will receive credit for materials separated off-site, such as at the curbside, and such materials will be considered part of the MSW received at the MWC for the purposes of calculating materials separation requirements. Finally, MWCs must not combust lead-acid vehicle batteries.

### 3.2.1.7 Nitrogen Oxides

Large MWCs will have to achieve a 150 ppmv $NO_X$ emission limit, corrected to 7 percent $O_2$ on a daily block 24-hour average basis. All MWCs subject to the $NO_X$ standard will also be required to achieve a mercury emission limit of 300 $\mu$g/dscm. The mercury limit is included because limited data indicate that there may be a link between $NO_X$ control and a decrease in mercury emission reduction across a spray dryer-fabric filter system.[6]

## 3.2.2 Guidelines

The pollutant to be regulated under the Guidelines is "MWC emissions." $NO_X$ is not included. The constituents of MWC emissions are discussed in the preceding section. The Guidelines are similar to the Standards in requirements with the main differences being the levels of the emission limits and the MWC size categories to which the limits apply.

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[6] See Chapter 5 for descriptions of control devices.

Unless noted in the following paragraphs, the Guidelines' requirements are the same as the Standards'. See Table 3.1.

#### 3.2.2.1 MWC Organics

A CDD/CDF emission limit of 10 ng/Nm$^3$ at 7 percent $O_2$ will be required at very large MWCs, and 125 ng/Nm$^3$ at all other MWCs, except that RDF MWCs with capacities less than 2,000 Mg/day will have a limit of 250 ng/Nm$^3$.

#### 3.2.2.2 MWC Metals

The Guidelines will limit PM emissions to 34 mg/dscm at 7 percent $O_2$ at very large MWCs, and to 69 mg/dscm at all other MWCs. Opacity will be limited to 10 percent.

#### 3.2.2.3 MWC Acid Gases

All very large MWCs will be required to reduce HCl emissions either by 95 percent or to a level of 25 ppmv. Large MWCs will have to achieve either a 50 percent HCl reduction or a 25 ppmv HCl emission level. Small MWCs are exempt from HCl control.

All very large MWCs will be required to reduce $SO_2$ emissions either by 85 percent or to a level of 30 ppmv. Large MWCs will have to achieve either a 50 percent $SO_2$ reduction or a 30 ppmv $SO_2$ emission level. Small MWCs are exempt from $SO_2$ control.

#### 3.2.2.4 Good Combustion Practice

This is the same as for the Standards.

### 3.2.2.5 ASME Certification and Operator Training

This is the same as for the Standards.

### 3.2.2.6 Materials Separation

This is the same as for the Standards.

## 3.3 Recordkeeping and Reporting

The recordkeeping and reporting requirements in the Standards are basically the same as those that will be imposed by the states under the Guidelines. Owners and operators subject to the Standards will be required to submit a notification of the intent to construct and to initiate operation of a new, modified, or reconstructed MWC. All MWC owners or operators will be required to submit the results of the initial performance test and performance evaluation of the continuous emission monitoring system (CEMS).

The Standards and Guidelines will require quarterly reports of CEMS drift tests and accuracy determinations, and reports of any periods when the minimum data requirements for CEMS were not met. Other quarterly reports that will be required are continuous compliance reports for $SO_2$, CO, opacity, and combustor operating parameters (load and temperature); excess emission reports; and for the Standards, compliance reports for $NO_X$. Annual reports of compliance with the CDD/CDF, PM, and HCl limits will be required, except that MWCs that are allowed to skip annual compliance tests would submit a simplified annual report. For the Standards, annual reports of mercury emissions also will be required.

Records, including results of emission tests, CEMS data, and documentation of employee training, must be maintained for two years and made available to enforcement personnel upon request.

# Chapter 4

# The Need for and Consequences of Regulatory Action

## 4.1 The Problem

Americans produce more and more solid waste each year; on a per capita basis, this country is among the top four producers of MSW. The yearly MSW generation rate has increased from 1960 to 1988 both in the total amount and in the per capita contribution. The rate is expected to continue to grow from a rate of 145 million Mg per year in 1988 to about 170 million Mg per year in the year 2000. To put it in a personal perspective, each of us contributes an average of 590 kg a year to the growing mountain of garbage. In 1960, Americans generated waste at a rate of 1.20 kg per person per day; by 1986, that figure had jumped to 1.62 kg, and if this trend continues the projected rate in 2000 is 1.78 kg per day. This 1.78 kg averages out to 4.4 kg per household per day. About one-half will come from households themselves, with the other half coming from commercial and other generators of MSW associated with our lifestyle.

MSW consists of all the major materials used in the modern industrial state. Table 4.1 presents estimated quantities and shares of these materials. Paper and paperboard products comprise over 35 percent of the total.

**Table 4.1**: Materials in the Municipal Waste Stream[a]
1986

| Materials | $10^6$ Mg | Percent |
|---|---|---|
| Paper and Paperboard | 45.6 | 35.6 |
| Yard Wastes | 25.8 | 20.1 |
| Metals | 11.5 | 8.9 |
| Food Wastes | 11.4 | 8.9 |
| Glass | 10.7 | 8.4 |
| Plastics | 9.4 | 7.3 |
| Wood | 5.3 | 4.1 |
| Rubber and Leather | 3.5 | 2.8 |
| Textiles | 2.5 | 2.0 |
| Miscellaneous Wastes | 2.5 | 1.8 |
| TOTAL | 128.1 | 100.0 |

[a] The composition of MSW varies widely from locality to locality. Published reports are inconsistent in their estimates of the composition.

Glass, metals and plastics are each about one-fifth to one-quarter of the paper and paperboard amount. Yard waste, for example, grass clippings, tree trimmings, and leaves, represent the second largest portion of MSW—about 20 percent.

We are having a very difficult time finding places to put our waste. Old landfills are filling up and closing rapidly. New solid waste facilities are difficult to site because of public resistance, commonly known as the "Not In My Backyard" (NIMBY) syndrome. Public resistance is not limited to landfills and combustors as even materials recovery facilities and recycling centers can be difficult to site. Nevertheless, landfills and combustors will still be necessary for the foreseeable future to handle a significant portion of wastes; but because of their potential harm to human health and the environment, and their long-term management costs, landfills and combustors will be supplemented increasingly with recycling and source reduction. Problems with MWCs can be minimized through good design and management.

Combustion of municipal waste is an attractive waste management option as it reduces the volume of waste by 70 to 90 percent. This translates into substantial extensions of the lifetimes of existing and future landfills. In the face of shrinking landfill availability, municipal waste combustion capacity in the U.S. is expected to grow rapidly, from the current U.S. capacity of 41,000 Mg per day to somewhere in the range of 105,000 to 230,000 Mg per day by the year 2000. As of early 1987, 111 MWC facilities existed in the U.S. and over 200 facilities were planned or under construction.

Direct landfilling accounts for the disposal of about 80% by weight of waste collected. About 10% of the waste collected in the U.S. was combusted in 1988 and 10% was recovered for recycling. Though direct landfilling currently predominates as the method of MSW disposal, it is becoming less attractive. There has been an increased recognition of the environmental damage associated with MSW landfills such as leachate contamination of groundwater and emissions of toxic air pollutants, not to mention unpleasant odors, noise, litter, truck traffic, and depressed land values. Although health concerns are often cited by the opponents of waste-to-energy facilities, air pollution emissions from MSW landfills—not from ash landfills—also represent a public health problem. EPA estimates that 138,000 Mg of landfill gas are emitted annually, and that number is climbing rapidly. Over 100 specific compounds have been detected in the gas; 11 are carcinogens and 12 others are the bearers of other adverse health effects. Landfill gas is one-half methane, a greenhouse gas comparable to the carbon dioxide ($CO_2$) produced by MWCs. Subsurface migration of methane accounts for 28 documented incidences of explosion or fire resulting in 9 deaths and 21 injuries.[1]

The concerns about potential threats to human health and the environment from MWCs are due to combustor emissions and ash. Pollutants emitted from MWCs are MWC organics (dioxins and furans, labeled CDD/CDF in this report, and other products of incomplete combustion), MWC metals

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[1] By mid-1990 EPA expects to propose air pollution emission standards and guidelines for landfills. Further information on these standards and guidelines, and on landfills in general, can be found in EPA Docket A-88-09. See Section 2.7 above on accessing the docket.

**(mostly trace metals, such as lead, cadmium, and mercury, all of which are condensable on particulate matter), MWC acid gases ($SO_2$, HCl, and to a lesser extent, HF), nitrogen oxides ($NO_X$, which also is an acid gas), carbon monoxide (CO), and particulate matter (PM). $CO_2$, a greenhouse gas, is also emitted, but is not being addressed by the Standards and Guidelines. The trace organic compounds and all trace metals (except mercury) are known or suspected carcinogens. Section 4.2.4 provides more detail on the health risks of these pollutants.**

## 4.2 Need for Regulation

### 4.2.1 Market Failure

**The U.S. Office of Management and Budget (OMB) directs[15] regulatory agencies to demonstrate the need for a major rule. The regulatory impact analysis must show that a market failure exists and that it cannot be resolved by measures other than Federal regulation. Market failures are categorized by OMB as *externality*, *natural monopoly*, or *inadequate information*. The latter includes situations where there may be a need for controls on entry into employment. The following paragraphs address the three categories of market failure.**

#### 4.2.1.1 Air Pollution as an Externality

**Air pollution is an example of a phenomenon called a "negative externality." This means that, in the absence of government regulation, market systems fail to make the generators of air pollution pay for the costs associated with that pollution. For an MWC operator, pollution is an unusable by-product that can be disposed of cheaply by venting it to the atmosphere. Left to their own devices, probably most MWC operators would treat airsheds as free goods and would not "internalize" the damage caused by emissions. This damage carries a very hefty price tag, and the receptors—the people who are the ones adversely affected by the pollution—are not able to collect compensation to offset their costs. They cannot collect compensation because the adverse effects, like materials damage and increased risks of morbidity and mortality, are by and large, non-market goods, that**

is, goods that are not explicitly and routinely traded in organized free markets.[2]

Consider an example. It may be somewhat unreal, but it illustrates why air pollution is a market externality. A young man estimates that over his remaining lifetime he has a risk of getting cancer of, let's say, 4 chances in 100. A new MWC is being built in his neighborhood, and he pessimistically calculates that the added pollution to his own environment will boost his odds of getting cancer to, say, 5 chances in 100. He walks up to the people building the MWC and offers to "sell his exposure" to the MWC's air pollution for a bargain basement price of just $5 a day. For his efforts he gets no more than a laugh. What's wrong? Most young men either would be unwilling to even consider such a transaction, or, if they were willing, they would not know enough about their futures and about the effects of the pollution to set such a precise price. Furthermore, even if they were willing and did have a price, they would not have the any good way of coming to terms with the MWC builders.[3] The builders have no incentive to pay anything to the receptors of the air pollution. No incentive, that is, unless government requires them to pay or to reduce the pollution.

How would it help to force MWCs either to compensate the people suffering the consequences of the pollution, or simply to reduce the pollution? Where there are negative externalities like air pollution, the market price of goods and services does not reflect the costs, borne by receptors of air pollution, generated in the course of producing the goods and services. Government regulation can be used to improve the situation. The Standards and Guidelines will force MWC owners and operators to reduce the air pollution they emit. With the Standards and Guidelines in effect, what MWC owners and operators must spend to combust MSW will more closely approximate the full social costs of combustion. In the long run, MWCs will be forced to collect in tipping fees and subsidies sufficient money to cover total combustion costs. Thus, tipping fees and subsidies will rise, communities accordingly will reduce their demand for combustion service, and hence less combustion service will be provided. The more the costs of pollution are internalized by the MWCs, the greater the improvement in the way the local MSW disposal market functions. If we could internalize all negative externalities—including, of course, those from landfilling

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[2] Litigation also is a possible route for collecting compensation, but it is slow and uncertain, and it may backfire.

[3] Again, litigation would be a possible route.

MSW—society's allocation of resources would be improved.

#### 4.2.1.2 Natural Monopoly

Local disposal markets are "natural" monopolies. There are large economies of scale in disposal operations; the heavy up-front capital needed to site and build a combustor acts as a barrier to entry; and in most situations transportation costs have been too high to ship MSW among regions for disposal. Unfortunately, the monopolistic (or oligopolistic) local markets that result from these natural conditions do not have the competitive market checks and balances that are needed to ensure the best utilization of society's resources. The Standards and Guidelines are not designed to address this problem, and will not reduce the tendency of local disposal markets toward monopoly or oligopoly.[4]

#### 4.2.1.3 Inadequate Information

The third category of potential market failure that sometimes is used to justify government regulation is inadequate information. In one key aspect this imperfection exists in the MWC industry, and justifies one small, but important, part of the Standards and Guidelines regulatory package.

Some MWCs have not acquired enough workers who have adequate knowledge of the proper operation of the MWC. Operator training and certification, which are measures to correct this situation, will improve the expertise of MWC workers. The existence of both pollution prevention technology and a regulatory mandate (including penalties) to use that technology does not, by itself, guarantee its use if employees do not have the skills and motivation needed to apply the technology. For this reason, and the judgment that operator training and certification in the control of MWC emissions will make a significant difference, EPA believes MWC operator training and certification are necessary components of the overall job of managing this country's air resources.

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[4] Federal legislation on interstate MSW disposal compacts and interstate shipping of MSW may be proposed to address this problem. Such a proposal is not part of the Standards and Guidelines.

What does operator training and certification involve? Proper operation of combustors is key to good combustion practice (GCP) and, therefore, is important to the reduction of organic emissions. Operation of MWCs is complex, and there are many interrelated parameters that influence emissions. The Standards and Guidelines specify limits for such things as temperature and emissions. Operator training and certification is needed to go "the extra mile"—to ensure that those who operate MWCs understand the combustion process and can implement GCP continuously. Thus, the Standards and Guidelines require (1) certification of the shift supervisor and chief facility operator by the American Society of Mechanical Engineers, and (2) the development by each MWC owner and operator of a site-specific training manual for the training of all other employees associated with the operation of the MWC. These other employees include control room operators, ash handlers, maintenance personnel, and crane operators.

There are other ways inadequate information could manifest itself. EPA does not argue that government intervention under the Clean Air Act is needed to provide households with information on how to find products that minimize the volume and toxicity of the products' resultant contributions to MSW, how to generate less waste, how to recycle what can be recycled, and how to dispose of what is left in a pollution-free manner. This kind of information flow will help people make wise consumption choices and MSW disposal choices, and may reduce the fear reflected in NIMBY political pressure. See Section 6.2.2 below. However, no part of the Standards and Guidelines is being justified on this aspect of the inadequate information category of market failure.

### 4.2.2 Price Instability

Price instability in the markets for recycled materials hinders the development of recycling as a vehicle for controlling MWC emissions. Price instability is not a market failure. The Standards and Guidelines will not correct it. EPA's requirement that municipalities separate out selected items before MSW is combusted means that separation costs need not be considered in deciding whether to recycle or landfill the items. Municipalities therefore will be more willing, but not necessarily happy, to recycle when the market price for recyclables is low. Thus, the Standards and Guidelines do not address price instability that indirectly causes higher

MWC emissions by hindering recycling, but do counteract the depressing effects of price instability on recycling.

The circumstances that give rise to price instability are many and diverse. Although the demand for goods and services produced from recycled materials is reasonably firm, the number and type of plants that can process recycled materials is small (but growing). This means that a single plant shutdown or similar event can trigger fluctuations in prices for recycled material. On the supply side, there are numerous independent, small public and private suppliers of recycled materials. Their resource base, MSW, exists in abundance regardless of the prices for recycled materials. Recyclers have no good information base for forecasting prices. Many recyclers are in the market as much for ecological and political reasons as for economic reasons. The list goes on. Current market conditions illustrate this instability. In 1989 recyclers in some local areas have been turning out old newspapers, mixed papers, mixed plastics, used oil, tires, compost, and ferrous scrap other than tin cans, in greater quantity than buyers are willing to absorb at a positive price. At the same time, in almost all local areas prices for old corrugated containers, office papers, single-resin plastics, glass, tin cans, and aluminum have been climbing.[7] Next year everything may be reversed. Sometimes oversupplied material is landfilled. In some respects the market for recycled materials resembles the market for farm commodities, where over- and under-supply is common.

### 4.2.3 Insufficient Political and Judicial Forces

Local NIMBY politics has forced some state and local governments, on their own initiatives, to control MWC emissions, but such efforts have been spotty. More often than not, NIMBY politics forces state and local governments into inaction on MWC siting applications.[5] One coherent and comprehensive approach to emission control (and hence to siting) is needed for the entire country. The piecemeal approach creates problems when pollution from a laxly-controlled MWC blows across state lines. It renders compliance by multi-state waste disposal firms that build and operate MWCs frustratingly difficult.

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[5] Language sometimes tells it all. Just as citizens and landowners striving to block the siting of an MWC have adopted "NIMBY" as their rallying cry, elected officials have adopted another to signify their desire to avoid siting controversy. It is unpronouncable, but it tells the story: "NDMT"—not during my term!

Citizens, as well as EPA, may sue state and local governments to force them to control MWC emissions. Litigation under both the CAA and RCRA is possible. However, such an approach is as piecemeal as is reliance on independent action by state and local government. Furthermore, litigation is expensive and chancy in comparison to direct regulation.

### 4.2.4 Harmful Effects of MWC Emissions

Health effects associated with municipal waste combustors come from two areas: air emissions and leachate from landfills that dispose of MWC ash residue. Leachate currently is controlled under RCRA Subtitle D, which requires liners for ash landfills along with leachate collection and monitoring systems. Only the problems due to air emissions are addressed in these Standards and Guidelines.[6] Exposure to air emissions can occur through inhalation, soil ingestion, the food chain, and dermal contact.

As mentioned in Section 4.1, pollutants that are emitted from MWCs include MWC organics, MWC metals, MWC acid gases, $NO_X$, CO, and PM. Table 4.2 lists some of these pollutants. To the credit of MWCs, combustion destroys pathogens and some harmful organics that otherwise might find their way to receptors.

Table 4.3 is a summary of the health and welfare effects of the pollutants that are emitted. Many of the pollutants are known or suspected to cause cancer (refer to Table 4.3). The acid gases ($SO_2$, HCl, HF) and $NO_X$ have adverse health effects, contribute to acid rain, and can cause soiling and materials damage. PM, $NO_X$, and $SO_2$ contribute to reduced visibility. Exposure to lead and mercury emissions can result in adverse noncancer health effects. $CO_2$ is of concern as a greenhouse gas. Welfare effects not listed in Table 4.3 include odor from unburned trash, truck traffic, and noise.

Combinations of various pollutants may have synergistic effects. Fortunately, most of the pollutants can be substantially reduced or eliminated with materials separation, good combustion practice, and air pollution control devices.

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[6] See Section 7.1.2 for further discussion of the ash problem. Fugitive dust from ash piles is yet another problem, but this fugitive dust is not treated here as air emissions.

**Table 4.2**: Pollutants Emitted by Municipal Waste Combustors

| | |
|---|---|
| **MWC Organics** | |
| Dioxins and furans[a] | |
| Includes: | 2,3,7,8-Tetrachlorodibenzo-*p*-dioxin |
| | 2,3,7,8-Tetrachlorodibenzofuran |
| | Tetra through octa Chlorodibenzo-*p*-dioxins |
| | Tetra through octa Chlorodibenzofurans |
| Benzene | Chlorinated benzenes |
| Chlorinated phenols | Polychlorinated biphenyls |
| Formaldehyde | Polynuclear aromatic hydrocarbons (Including Benzo-a-pyrene) |
| **MWC Metals** | |
| Arsenic | Beryllium |
| Cadmium | Chromium |
| Copper | Lead[b] |
| Mercury | Nickel |
| **MWC Acid Gases** | |
| Sulfur dioxide[b] ($SO_2$) | Hydrogen chloride (HCl) |
| Hydrogen flouride (HF) | |
| **Criteria Pollutants**[c] | |
| Particulate matter (PM) | Carbon monoxide (CO) |
| Nitrogen oxides ($NO_X$) | |

[a] The family of dioxins and furans are also referred to as CDD/CDFs. Dioxins and furans are products of incomplete combustion.

[b] Sulfur dioxide and lead are also criteria pollutants.

[c] Criteria Pollutants are those for which National Ambient Air Quality Standards (NAAQSs) exist.

**Table 4.3**: Some Health and Welfare Effects of MWC Emissions

- **MWC Organics**
  - Mortality, morbidity
  - The following are carcinogens:
    - Arsenic
    - Beryllium
    - Cadmium
    - Chromium$^{+6}$
    - Nickel
    - 2,3,7,8-tetrachlorodibenzo-*p*-dioxin
    - Benzene
    - Benzo-a-pyrene
    - Hexachlorobenzene
    - Trichlorophenol
    - Polychlorinated biphenyls
    - Formaldehyde
- **MWC Metals**
  - **Lead**
    - Retardation and brain damage, especially in children
    - Hypertension
  - **Mercury**
    - Central nervous system injury
    - Renal dysfunction
- **MWC Acid Gases**
  - **Hydrogen Chloride**
    - Materials damage
    - Dental erosion
    - Acid rain
- **MWC Acid Gases (Continued)**
  - **Sulfur Dioxide**
    - Mortality, morbidity
    - Respiratory tract problems, permanent harm to lung
    - Soiling and materials damage
    - Acid rain
    - Reduced agricultural yield
- **Nitrogen Oxides**
  - Ozone formation
  - Acid rain
  - NO$_2$: respiratory illness and lung disease
- **Carbon Monoxide**
  - Cardiovascular, nervous, and pulmonary systems effects
  - Reduced exercise capacity
- **Particulate Matter**
  - Mortality, morbidity
  - Eye and throat irritation, bronchitis, lung damage
  - Impaired visibility
  - Soiling and materials damage

## 4.3 Consequences of Regulation

### 4.3.1 Consequences if EPA's Emission Reduction Objectives are Met

**Allocation of Resources.** There will be improved allocation of resources in the MSW combustion market. Specifically, more of the costs of the harmful effects of MSW combustion will be internalized by MWCs. This, in turn, will affect municipalities' decisions on whether, how, and how much to combust. To the extent these newly-internalized costs are then passed along to the people who generate the MSW, and to the extent these people are free to buy as much or as little combustion service as they wish, they will purchase less (relative to their purchases of other competing services). If this same process of internalizing negative externalities occurs throughout the entire MSW generation and disposal "industry," so that packaging manufacturers, landfill operators, recyclers, and the like, are all affected, an economically optimal situation is approached. This is the situation when the marginal cost of resources devoted to MSW disposal equals the marginal value of the disposal to the people who are trying to get rid of the MSW. There are many "ifs" in this chain of events. It is easy to cite situations where the air pollution control costs will not ripple through as suggested here and affect decisions by the generators of MSW. Nevertheless, in the aggregate and in the long run, the Standards and Guidelines will move society toward this economically optimal situation.

**Emissions Reductions and Air Quality.** Emissions of air pollutants will be reduced. (See Chapter 10.) Air quality will improve. (This analysis does not translate emission reductions into ambient air quality improvements. However, estimates of air quality improvement are intrinsic to the benefits analysis. See Chapter 12.)

**Costs and Benefits.** The national annual cost of emission control will increase by about $500 million by 1994. Benefits EPA can quantify and express in monetary terms will exceed $100 million annually for the nation. These benefits include reductions in some morbidity and mortality associated with direct inhalation of the pollutants. However, EPA has not quantified several types of benefits. (See Chapters 10 and 12.)

**Energy.** A small increase in energy to operate control equipment will be needed. Most MWCs will produce steam that will be used to produce electricity for sale. The power demand to operate the pollution control equipment will be less than 3 percent of the electricity an average MWC generates. In total, the Standards and Guidelines are expected to require about 650,000 MWh per year, which represents about 25 percent of the power output of one typical power plant, plus about 820 TJ of natural gas per year, by 1994.[7]

**Water Quality.** No significant water pollution impacts are projected because none of the emission controls on which the Standards and Guidelines are based produces a wastewater stream. The potential increased toxicity of fly ash will not affect ground or surface water because RCRA Subtitle D regulations (possibly as modified by pending legislation) will require landfill liners and leachate collection systems where fly ash is landfilled.

**Solid Waste.** Solid waste impacts will be minimal. GCP tends to reduce the generation of ash, but acid gas control will increase it. Overall, MWC ash generation will increase in mass about 4 percent for existing MWCs, and about 11 percent for new MWCs. This translates into an additional 663,000 Mg ash per year by 1994.[8] This amount is trivial in comparison with the 70 to 90 percent MSW volume reduction accomplished by combustion. In addition to the reducing effect of GCP on ash, materials separation is likely to further reduce by half ash generation per Mg of MSW combusted. However, the net impact of materials separation is uncertain because some separated material may be landfilled.

**Source Reduction and Recycling.** Political and consumer pressure for source reduction measures (Section 5.2) will increase. Recycling (Section 5.3) will increase. Once recyclable materials are separated from combustor feed, there will be an economic incentive to find markets for them. Such markets exist now on a national scale, and many exist even in small municipalities. New markets will be created.

**Technological Innovation.** CAA §111 regulations serve to disseminate both pollution control and combustion technology, and to stimulate further technological development. MWC builders have the freedom to seek the most economical way to comply with performance standards. The Standards and Guidelines may promote the sharing of combustion technology with Europe and Japan, and probably will open new directions of research in FBC technology.

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[7] Data are based on the assumption that the Standards and Guidelines will not alter municipalities' plans to retain and/or build MWCs. This is the no-substitution scenario and is described in Chapter 9.

[8] Footnote 7 also applies to these data.

**Public Awareness.** The fact that MWCs will cost more will heighten public awareness of the MSW disposal problem, and will increase the public's acceptance of source reduction and recycling measures.

**State Regulation and New Source Review.** State regulatory programs will be strengthened. The Standards and Guidelines will be delegated to the states for enforcement. Assuming states do not pull resources from other programs to handle their enlarged responsibilities, there will be a natural strengthening of state air pollution control staffs. Recognition that the Standards and Guidelines are effectively reducing emissions will expedite the state process of reviewing applications for new MWCs and issuing permits for their construction and operation. There will be less controversy involved. Finally, state regulations will be uniform, and the disadvantages of the piecemeal approach to emission regulation will be avoided.

**Miscellaneous.** For the most part, the potential consequences listed above are reasonably unambiguous. The following are notes on potential consequences where impacts are less clear.

> **Substitution.** EPA conducted a limited analysis of how the Standards and Guidelines might affect municipalities' MSW disposal decisions. The Guidelines will have relatively little impact on existing MWCs. In a few instances some older MWCs may be closed to avoid the cost of retrofitting air pollution control devices. The Standards will cause some shift away from RDF and mass burn MWCs. Also, the overall construction rate for MWCs may decline slightly from what it would be if there were to be no regulation. These effects are heavily caveated, and *do not* consider some upcoming regulatory costs for landfills. How municipalities choose among MSW disposal technologies is changing rapidly. See Chapters 9 and 10.
>
> **Regionalization.** There may be increased economies of scale for MWCs. Historically, municipalities have found that the bigger you build an individual combustor of any particular type (mass burn, modular, etc.), the cheaper it will be to combust each Mg of MSW.

With the Standards and Guidelines in force, this will be even more true. Where municipalities' selections of minimum combustor size and technology *are not* influenced by the Standards and Guidelines, municipalities will feel these added economies of scale and may seek ways to capitalize on them by building larger MWCs. Thus, local governments in some metropolitan regions may have more incentive to join together in regional authorities that can build and operate large MWCs. There may be more regionalization of MSW disposal activities. However, where municipalities' selections of minimum combustor size and technology *are* influenced by the Standards and Guidelines, there may be no additional push toward regionalization of disposal services. For one thing, some municipalities may downsize new MWCs as a result of materials separation requirements and possibly, if the planned MWC size is in the 225 to 300 Mg range, to avoid installation of best (instead of good) acid gas control.[9] For another thing, some municipalities may switch from a technology with high returns to scale, such as mass burn, to another with lower returns, such as modular.

**Industry growth**. The growth of the MWC industry—MSW throughput, capacity, capacity utilization, jobs, market share, revenue, etc.—may get a boost from the Standards and Guidelines if cleaner MWC operations improve the public's acceptance of combustion. On the other side, the cost of air pollution control could depress MWC industry growth. See the discussion of substitution in Chapters 9 and 10.

**Landfill Utilization**. The utilization of landfill capacity may improve if the Standards and Guidelines stimulate the construction of new MWCs. On the other hand, the utilization of landfill capacity may worsen if fewer MWCs are built or if MWC ash disposal requires extra-wide buffer strips, extra soil cover, or extra-safe sites compared to what is required for "ordinary" RCRA Subtitle D landfills.

**Distributional Impacts**. The way Americans pay for MSW disposal, and therefore which firms, municipalities, waste generators, or other groups will end up paying, may change. EPA has studied what the distribution of costs would be *if* households had to pay everything, and alternatively, *if* local governments (taxpayers) had to pay everything. See Chapter 11. However, this analysis does not reveal how private firms, consumers, and governments will share the final burden "after the dust settles."

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[9] See Chapter 6 for an explanation of "best" and "good" acid gas control.

**Other Federal Programs**. The effects of the Standards and Guidelines on other Federal regulatory programs have not been investigated. These programs include those of the Occupational Safety and Health Administration, and various EPA activities relating to the Superfund, to pesticide control, and to treatment of wastes not covered by RCRA Subtitle D.

### 4.3.2 Consequences if EPA's Emission Reduction Objectives are not Met

The most obvious consequence of failure to meet EPA's emission reduction objectives would be more delays and controversy in the siting and permitting of new MWCs. Another consequence would be the need to revisit the nation's goals set forth in *An Agenda for Action*, because the Standards and Guidelines are key segments of the road to the environmentally sound MSW disposal practices described in that report.

Poor compliance would result in both emissions reductions and benefits that are not as large as EPA is projecting. However, costs are not likely to be as large either. Whether it is noncompliance from ignorance or error, or from willful intent, or simply slow compliance due to municipalities exercising legal delays, poor compliance can save some MWCs money. Unless states respond by pouring more resources into enforcement, then poor compliance could bring with it smaller aggregate nationwide control costs. EPA has not included an allowance for poor compliance in its estimates of emissions reductions. This is because the potential effects of poor compliance are expected to be minor.

If APCDs degraded rapidly over time or in some other way did not function as expected, there could be a misallocation of resources. This situation is very unlikely because the Standards and Guidelines are based on demonstrated technology. Other ways the regulations could fail are conceivable. Perhaps some new substance is added to MSW that defeats APCDs, or future research will reveal that EPA decided to control the wrong set of pollutants.

The Clean Air Act provides a remedy for all the above situations, namely, an automatic review of §111(b) regulations at least every four years. Although the automatic review provision is directed only to NSPSs, other provisions of the Act ensure that noncompliance with the Guidelines would trigger review and revision of those Guidelines.

# Chapter 5

# Control Techniques

## 5.1 Integrated Waste Management

Integrated waste management[14], like motherhood and apple pie, is something anyone would support. Unfortunately, until recently ignorance, not opposition, kept integrated waste management from widespread acceptance and use. Not until the current MSW crisis hitched a ride into our collective consciousness aboard the ill-fated 1987 "garbage barge" have so many communities recognized the need for a coordinated attack on all aspects of the MSW dilemma. As explained above in Section 2.1, integrated waste management calls for the complementary use of source reduction, recycling, combustion, and landfilling to safely, economically, and effectively handle MSW with the least adverse impact on human health and the environment. The goal set by EPA for the nation is to have 25 percent of the MSW stream diverted by source reduction and recycling by 1992 (up from just under 10 percent in 1988). Also in the nation's goal: 55 percent landfilling (down from 80 percent) and 20 percent combusting (up from slightly over 10 percent). The emphasis on increased source reduction and recycling ties in with a broader EPA goal of pollution prevention, a goal the Agency is applying to all types and sources of pollution. EPA believes that responsibility for meeting MSW goals lies with all of us: producers, consumers, waste management companies, processors and handlers of secondary materials, and all levels of government.[1]

The next two sections of this chapter discuss source reduction, materials separation, and recycling. These components of integrated waste management are key to the successful planning and operation of MWCs. However, except for prohibitions of the burning of selected items, these components are largely, but not completely, outside the scope of CAA §111 regulation. Sections 5.4 and 5.5 address control techniques that are the traditional subjects of CAA §111 regulation. The concluding section explores the question of why our existing economic, political, and legal institutions will not be able to ensure full application of the control techniques in the absence of further EPA regulation.

## 5.2 Source Reduction

Source reduction is a set of strategies relating to the design, manufacture, packaging, and use of products so as to reduce the quantity and toxicity of MSW. It is a part of EPA's national strategy for solid waste and will be encouraged, but not required, by the Standards and Guidelines. Its advantages include not just reduced MWC emissions, but lower MSW disposal costs, and conservation of resources (materials, energy, and land).

Source reduction is the job of consumers, producers, and governments alike. They can purchase, patronize, and/or use

- Cloth diapers instead of disposable diapers (A staggering 18 billion of them every year clog our combustors and landfills!),
- Paper bags instead of plastic bags,
- Photocopiers that print on both sides,
- Restaurants that do not use plastic utensils and food containers,

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[1] EPA's goals for integrated waste management include encouragement of cooperation among local governments, but do not address directly the potential regionalization of MSW disposal services. In this regard, the Standards and Guidelines may provide positive economic incentive for local governments to go in together if they are considering combustion of MSW. This is because the cost of emission control per Mg of MSW combusted generally is smaller for large MWCs than it is for small MWCs.

- Fewer battery-operated products,
- Degradable products and longer-lasting products (such as degradable plastics and radial auto tires), and
- Fewer pesticides and organic solvents.

Producers must not wait for regulations that will internalize into production costs the social costs of disposing of products after they have outlived their usefulness. The producers' job right now is to design and use packages that will reduce the resources needed to dispose of used packages, and to produce products and packages that are degradable, recyclable, and/or more durable, and are less toxic. Government's role is to encourage research, provide market incentives, educate, and where all else fails, regulate—all with source reduction and recycling as goals.

Source reduction affects combustion in the same manner as does recycling. These effects are discussed in the next section.

## 5.3 Materials Separation and Recycling

Materials separation and recycling involve the removal, processing, and possible reuse or marketing of glass, metals, paper, and other materials in the solid waste stream. Materials separation and recycling may be done by the waste generator on site, or by a service entity at a central site, which may be a transfer station, the MWC site, the landfill site, or a site specifically devoted to materials separation and recycling. Recycling includes composting, but usually is not considered to include the recovery of electricity and steam from the combustion of MSW, the recovery of useful or marketable products from MWC ash, or the recovery of landfill gas.[2]

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[2] There is no generally accepted definition of recycling, or clear distinction between source reduction and recycling. Some measures, such as container deposit laws, seem to fall in both categories. On the other hand, some activities seem to fall in neither category. For example, some call the generation of steam and electricity resource recovery. EPA uses the term "materials separation" here to focus attention on actions that could be required under CAA §111 to preclude the introduction into combustors of items, like lead-acid batteries, that produce undue pollution when heated or combusted, and items that hinder good combustion.

Source reduction and recycling occasionally are in conflict with one another. For example, plastic food containers have less weight and volume than equivalent glass containers, and therefore switching to plastic can be considered a source reduction measure. However, in many cases glass is more readily recycled than is plastic.

The Standards will require all MWCs to prepare, have approved, and follow a plan for materials separation. The separation may be on-site mechanical separation, on-site manual sorting, a community materials separation program, or any combination of these procedures. MWCs must demonstrate removal of one or more of the following materials: paper, paperboard, metals (including appliances), glass, plastics, and household batteries. On an annual average weight basis, these removed materials must comprise at least 25 percent of the total MSW received at the MWC. (No credit will be allowed for yard waste in excess of 10 percent of the total MSW received.) An MWC will receive credit for materials separated offsite, such as at the curbside, and such materials will be considered part of the MSW received at the MWC for the purposes of calculating materials separation requirements. Finally, MWCs must not combust lead-acid vehicle batteries.

Materials separation will reduce MWC emissions in two ways. First, the country will not need as much MWC capacity as it would without significant materials separation.[3] If less MSW is burned, MWC emissions will be reduced. Second, preventing the heating or combusting of the materials to be separated will reduce emissions from the remaining MSW. Examples of expected emission reductions:

- MWC Organics
  - From yard wastes containing pesticides and chemical products
- MWC Metals
  - Lead from lead-acid batteries, lead-based inks on paper, lead solder and lead plating on ferrous metals, lead-containing glass, and lead-containing stabilizers in plastics and pigments
  - Mercury from fungicides in paper

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[3] The effect of materials separation on the utilization of combustion for disposal of MSW has not been analyzed. See Section 8.2.

  - Zinc and cadmium from plating on ferrous metals
  - Cadmium from stabilizers in plastics and pigments

- MWC Acid Gases
  - $SO_2$ from sulfur-laden paperboard
  - HCl from chlorine-bleached paper and polyvinyl chloride plastics

- $NO_x$
  - From nitrogen in yard wastes

Materials separation will indirectly contribute to emission reductions elsewhere in the economy by

- Improving energy recovery efficiency at MWCs so that there can be less reliance on fossil fuel power generation, and
- Reducing energy requirements for extracting and processing virgin materials.

If materials separation requirements are placed on MWCs but not on *all sizes* of landfills, and if materials separation proves to be more costly than EPA anticipates it will be, then materials separation requirements may have the perverse effect of *increasing* landfill air emissions. This would happen because municipalities would divert MSW from combustors to landfills to avoid materials separation costs.

Source reduction, materials separation, and recycling may alter the cost effectiveness of APCDs. There are two separate effects. First, enough lead, cadmium, or similar material might be eliminated from fly ash to effect its classification as nonhazardous waste.[4] Second, because the cost per Mg of pollutant removed from flue gas increases as the concentration of pollution in untreated flue gas decreases, and source reduction will decrease the concentration of pollution in untreated flue gas, the cost effectiveness of APCDs will worsen. These two effects on cost effectiveness are not analyzed here because EPA does not rely on cost-effectiveness criteria to support regulation of MWCs.[5] Cost effectiveness is an elusive measure when it comes to evaluating MWC control devices because each device controls more than one pollutant.

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[4] At the time of this writing EPA and Congress have not resolved a policy for disposal of MWC ash. This potential effect on cost effectiveness of APCDs is relevant only to situations where it will cost more to landfill ash after the introduction of an APCD because operation of the APCD causes an increase in the toxicity of the ash. See Chapter 7 for more discussion of the ash problem.

Source reduction, materials separation, and recycling also may affect the selection of combustor and energy recovery technology. In the process of selecting combustor and energy recovery technology, a decision to employ centralized materials separation and recycling may tip the scales in favor of FBC technology over modular or mass burn technology. Removal of aluminum and glass from MSW allows more efficient grate design. Furthermore, if materials separation and recycling affects the energy content of the MSW that will be combusted, it may correspondingly affect how that energy is harnessed. Unfortunately, there is no easily generalizable evidence on how materials separation and recycling affect the energy content of MSW.

## 5.4 Good Combustion Practice

Good combustion practices alter the combustion process to reduce emissions of MWC organics. GCP includes the proper design, construction, operation, and maintenance of an MWC. Organics can originate in waste feedstreams, combustion reactions, or post-combustion reactions in the flue gas.

A more thorough combustion process reduces the formation of MWC organics. GCP promotes proper combustion through attention to the following combustor design and operating conditions:

- Uniform waste feed rates,
- Amount and distribution of combustion air,
- Adequate combustion temperature and residence time,

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[5] See Section 6.3.2. Although EPA does not *rely* on cost effectiveness to support regulation of MWCs, EPA does *consider* cost effectiveness in situations where the question is simply one of identifying the most economical APCD or control method for a particular pollutant.

- Mixing,
- Particulate matter carryover,
- Downstream flue gas temperature control, and
- Combustion monitoring and control.

The optimal levels of these parameters vary by combustor type. Because of the complex relationship between these parameters and good combustion, optimal performance is best determined experimentally for each MWC. Operator training and certification, and the monitoring of carbon monoxide emissions, operating loads and PM control inlet temperatures ensure that GCP is maintained continuously.

The post-combustion formation of MWC organics is minimized through flue gas cooling to 230°C or below prior to the PM collection device. Flue gas cooling is achieved through the use of water sprays, dilution air, or a heat exchanger.

## 5.5 Post-Combustion Control Devices

Electostatic precipitators (ESPs) and fabric filters (FFs) are the most frequently used PM control device for existing MWCs. Other less effective devices, such as cyclones, electrified gravel beds, and venturi scrubbers, have been used at a few MWCs but are not expected in new MWC plants.

ESPs subject the flue gas to a high voltage field, which electrically charges the dust particles, causing them to migrate to a grounded collection plate. Periodically the plates are rapped or washed to dislodge the dust layer and the resulting ash is collected in a hopper.

Fabric filters (also called baghouses) are increasingly popular for PM control because they offer the potential for acid gas control when used with a spray dryer. PM collects on filter bags as flue gas flows through the fabric filter. The resulting filter cake increases the pressure drop across the bags to a preset limit, at which time the cake is removed by reversing the air flow or pulsing the bag with compressed air. The pulse jet system is cleaned with the fabric filter on-line or off-line. The reverse-air FF is taken off-line for cleaning.

ESPs or FFs are effective in reducing PM emissions to 34 mg/dscm or less at 7 percent $O_2$ when they are well designed and operated. Along with the fine particulates from MWC flue gas, ESPs and FFs remove over 97 percent of MWC metals (with the exception of mercury). ESPs and FFs alone are not effective in removing mercury from MWC flue gas. Some mercury control is achievable using a FF in conjunction with acid gas controls. Mercury controls on MWCs remain under investigation.

Control of MWC acid gases is achieved by the injection of dry or slurried alkali sorbents (such as lime) into a section of flue gas duct or furnace, or spray drier. Unreacted sorbent and reaction products (and fine particulates) are collected by an ESP or FF. Dry sorbent injection (DSI) achieves 50 percent $SO_2$ control and 80 percent HCl control in new MWCs using duct injection. Furnace injection, considered more of a retrofit technology, still achieves 50 percent $SO_2$ control, but achieves somewhat lower HCl control (such as 50 percent).

Spray drying followed by a FF is a higher performance technology for MWC acid gas control than either duct or furnace DSI. Properly designed SD/FF systems achieve 85 percent $SO_2$ reduction and 95 percent HCl reduction on a 24-hour average. SDs also control MWC organics and metals (including mercury) to a greater degree. The spray drying process consists of injecting atomized lime slurry into a SD vessel, where the water evaporates to cool the flue gas and the lime reacts with the acid gases to form salts. The salt particles are removed with the fine particulates by a FF. SD performance is determined by the SD outlet temperature, which is controlled by the water content of the slurry, and the lime-to-acid stoichiometric ratio. Lower temperatures, favoring effective acid gas removal, are balanced against the need to adequately dry the SD reaction products prior to the FF. Generally, SDs operate at temperatures near 150°C.

# Chapter 6

# Regulatory Options

## 6.1 Complementary Approaches

Just as there are several ways to skin a cat, there are several ways to reduce emissions from MWCs. Chapter 6 describes some of these ways. First, suppose there is to be *no* additional arm-twisting, command-and-control EPA regulation of MWC emissions. What then? Perhaps state and local governments could shoulder the burden of developing and implementing up-to-date regulations, or perhaps Federal, state, and local governments could experiment with economic incentives, such as deposit laws or threats to deny recalcitrant municipalities their shares of highway funds. Second, suppose there *is* to be additional command-and-control regulation of MWC emissions. What then? There are many choices as to which MWCs might be regulated, how, and to what degree. These with-and-without-direct-EPA-regulation approaches are the topics of this chapter.

EPA's *Agenda for Action*[14] and the Congressional Office of Technology Assessment's *Facing America's Trash*[7] present a strong case for a comprehensive, coordinated, and coherent national attack on the MSW disposal problem. EPA believes that regulation of MWC emissions through the Standards and Guidelines is an essential *component* of the solution to that problem. State and local action, and economic incentives, are *complements* to the Standards and Guidelines—*not alternatives.* Governmental actions affecting MSW disposal must be many and coordinated if this country is to achieve the environmentally sound disposal of MSW.

## 6.2 No Additional EPA Regulation

### 6.2.1 State and Local Action

The CAA requires each state to develop and implement measures to attain and maintain EPA's national ambient air quality standards. Each state assembles these measures in a document called the State Implementation Plan (SIP). SIPs must be approved by EPA, and EPA is empowered to compel revision of plans it believes are inadequate. EPA may assume enforcement authority over air pollution control programs any state fails to implement. The Standards and Guidelines will become parts of each state's SIP, and enforcement authority will be delegated to the states. If EPA were not to promulgate the Standards and Guidelines, states could, in theory, still put the unofficial Standards and Guidelines in their SIPs. In the past, *some* CAA §111 regulations EPA has prepared but not promulgated have been adopted by *some* states, but usually only for enforcement in nonattainment areas. (Nonattainment areas are small regions, generally not crossing state lines, where air quality is worse than permitted by EPA's air quality standards.)

All states have in their SIPs procedures for reviewing applications for permits for the construction and operation of new, large, potential sources of air pollution, and procedures for attaching conditions to the approval of those permits. These new source review procedures apply to most MWCs. As a general rule, states approve applications for new MWCs only if the MWCs will agree to install and operate best available control technology (BACT). CAA §111 regulations are used by states to help define BACT. However, BACT for some types of MWCs, such as those employing fluidized bed combustion, for some components of what is called here "MWC emissions," and for $NO_X$ from MWCs, is not fully defined by existing §111 regulations. (See Section 2.2.1 for the current coverage of §111 regulation of MWCs.) Lack of full and clear definitions of BACT delays the process of new source review and results in incomplete control of all pollutants of concern.

Some SIPs contain provision for emission rights trading, emission density zoning, and other control techniques that could be applied to MWCs. Most states have programs to control air toxics—toxic organics and metals that are too numerous in number for all to be effectively addressed by CAA

§111 or §112. Some states may employ some of the economic incentives described in Section 6.2.2 below.

EPA believes that reliance on state and local action is not a viable substitute for the Standards and Guidelines. This belief holds even if EPA were to step up research and technology transfer programs to assist state and local governments. In the absence of the Standards and Guidelines, state and local action would be a fractionated, inefficient, and incomplete societal response to the problem of MWC emissions. The reasons are many. In brief: Air pollution crosses state lines. MSW and MWC ash is shipped across state lines. Firms that construct or design plants for many states have an inordinate burden trying to meet multiple, diverse state and local regulations. Some states are reluctant to require the best APCDs unless all states will be requiring them. Finally, EPA regulations, most of which are enforced by state and local officials, often are needed to give those officials the clout needed to command the respect of the regulated community.

### 6.2.2 Economic Incentives

There are probably more ways to use the marketplace to motivate MWC emission reductions than there are MWCs. This section lists a selection of economic proposals for doing just that, some tried, some untried.[1] Most of these require more study, and most would need to be based on legal authorities other than the CAA as it currently reads. Most relate to source reduction, materials separation, and recycling; comparatively few relate to GCP and APCDs. Section 4.2 above explains why market forces presently are not adequate to obviate the need for the Standards and Guidelines. It will take considerable time to study and select the best economic incentives, to develop suitable statutory authorities, to prepare and promulgate the incentives, and thence to implement them. Therefore EPA, in evaluating these economic incentives for their utility as MWC emission reduction measures, concludes that economic incentives in general should be complements to, and not replacements for, the Standards and Guidelines.

The following is a partial itemization of the economic incentives EPA initially considered as possible non-regulatory means for reducing MWC emissions. Each has the potential to affect MWC emissions, but true to the old adage "Everything affects everything else," each has the potential to affect other things as well. The reader is cautioned that some of these incentives could have unacceptable downsides.

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[1] See *Facing America's Trash*[7] for an excellent review of economic incentives related to MSW disposal.

EPA can develop and disseminate *information* to

- Facilitate markets for recycling
  - Standardization of terms, such as delineation of exactly what is and is not to be considered MSW in calculations of the percent of MSW that is recycled
  - Periodic inventories of recycling programs and activities
  - Statistics on recyclable materials: prices, markets, availability, quantities, shipping methods, uses, toxicity, etc.
- Advise consumers and MSW generators how to be part of the solution rather than part of the problem
  - Educational and advertising campaigns
  - Guide for the on-site composting of yard waste
  - Product labels that indicate products' contributions to the MSW problem
- Advance the technology of combustion, pollution control, and recycling
  - Research on GCP, APCDs, and combustion technology
  - Research on the separation, processing, and use of recyclable materials
  - Clearinghouse for technology transfer
  - Federally funded MWC operator training and certification programs

EPA (or governments in general) can assess *fees*, *penalties*,[2] or *taxes*, or restructure *subsidies*, or grant *exemptions* from regulations, to

- Force producers to internalize the disposal cost of products

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[2] Some fees and penalties are, of course, enforcement tools for direct regulation.

  - A waste added tax somewhat equivalent to a value added tax

- Give households and other MSW generators incentives to generate less MSW
  - Disposal fees to augment sales and use taxes
  - Restructuring of local taxes and fees so that households and other MSW generators pay for MSW disposal according to the amount of MSW collected from them

- Significantly reduce or eliminate selected items in the MSW stream
  - Penalties for combusting lead-acid batteries, or subsidies to not combust them.

- Encourage recycling
  - Tax breaks for producing or using recycled material
  - Partial relief from regulations governing the highway transport of hazardous substances, for salvaged batteries and other items to be recycled
  - Subsidies to export recycled material
  - Restructuring of taxes (mineral depletion allowances, capital gains provisions, investment tax credits, depreciation schedules, etc.), freight rates (paper, pulp, etc.), international trade quotas and duties (paper, pulp, etc.), and governmental services (logging roads, forest management services, mineral surveys, etc.) to ensure that virgin materials are not underpriced *vis-à-vis* recycled material
  - Withholding of highway or other Federal funds where states and/or local areas fail to prepare and implement recycling programs

- Reduce MWC emissions
  - Tax credits for installation of pollution control equipment
  - Emission fees
  - Exemption of an individual MWC's ash from hazardous waste regulations if the hazardous classification results from operation of an EPA-approved APCD

Governments can *purchase*, have others purchase, or *ban* products according to whether and how the products affect the amount of MSW, the toxicity of MSW, the use of recycled material, and/or MWC emissions, to

- Stimulate source reduction, materials separation, and recycling
  - Procurement of items made from recycled material, perhaps by allowing the cost to be 10 percent over that for items made from virgin material
  - Procurement of less-toxic products
- Stabilize recycling markets
  - Price supports and other analogs of farm support programs
- Reduce MWC emissions
  - Revision of PURPA[3] avoided-cost calculations to establish more favorable sales prices for electricity cogenerated by MWCs that reduce emissions

Governments can implement *deposit laws* to

- Reduce MWC emissions and achieve other environmental goals
  - Beverage container deposits
  - Battery deposits

## 6.3 EPA Regulation

### 6.3.1 Development of Regulatory Alternatives

EPA elected to use CAA §111 as the basis for controlling MWC emissions. This decision triggered a long research effort to identify and classify

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[3] The Public Utility Regulatory Policies Act of 1978 (PURPA) stipulates that electric utilities must purchase electricity generated by MWCs, paying a rate that equals, but does not exceed, the utility's avoided cost of generating or purchasing that electricity. Needless to say, there is extensive leeway and controversy in calculating the avoided cost.

MWCs by type and size, to list all the emission control devices and practices applicable to each type and size of MWC, to arrange the emission controls in order of effectiveness (which usually means in order of cost) for each type and size of MWC, and then to collapse these bewildering matrices that match MWCs with controls into a short, understandable, and coherent list of regulatory alternatives. Types and sizes of MWCs are explained in Chapter 7. Table 6.1 shows in very general terms a hierarchy of combustion and post-combustion controls. EPA decided to keep $NO_X$ controls separate from this regulative alternative structure, and to keep pre-combustion controls (materials separation) separate as well. From this beginning, the regulatory alternatives were formed. The process of their development is described in more detail in the *Federal Register* preambles.[4]

**Table 6.1**: MWC Emissions Control Technology

| Technology[a] | Cost | Pollutant |
|---|---|---|
| GCP: Good Combustion Practice | Low | CO & Organics |
| PM Control | | PM & Metals |
| Good Acid Gas Controls (Dry Sorbent Injection & ESP or Fabric Filter)[b] | | Acid Gases & Organics |
| Best Acid Gas Controls (Spray Dryer & Fabric Filter) | High | Acid Gases & Organics |

[a] These technologies generally are used in combination.

[b] This principally applies to retrofit of existing MWCs. ESP = electrostatic precipitator.

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[4] These preambles will accompany proposal of the Standards and Guidelines in the *Federal Register* later this year.

Once defined, the regulatory alternatives went through numerous revisions before assuming their present form.

Normally, EPA relies heavily on cost/effectiveness (C/E) analysis not just in the development of regulatory alternatives, but in selecting the regulatory alternative that will constitute the basis for a regulation.[5] If the regulation will constitute a major rule within the meaning of Executive Order 12291, EPA supplements C/E analysis with a benefit-cost methodology.[6] Neither procedure has fit well with the Standards and Guidelines. The problems with benefit-cost analysis are discussed in Chapters 12 and 13. Section 6.3.2 below recounts some of the thinking that has caused EPA to turn away from traditional C/E analysis for selecting regulatory alternatives for promulgation. Without definitive C/E and benefit-cost findings to support the Standards and Guidelines, EPA instead relies on judgment about how the regulatory alternatives are constructed and about which regulatory alternatives are the most protective of health and welfare, yet affordable and equitable.

### 6.3.2 Role of Cost Effectiveness

EPA has used C/E analysis to identify regulatory alternatives that control pollutants at an incremental cost in the range of values some analysts believe reflect the value to society of the associated incremental reduction in the pollutants. Incremental C/E ratios are calculated for each step up the stringency ladder, from the baseline through the regulatory alternatives. For CAA §111 decisions, EPA then chooses a regulatory alternative considering cost effectiveness (along with other factors such as affordability, equity, and feasibility). However, for the Standards and Guidelines, there are several analytical problems that have rendered this C/E approach less reliable.

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[5] EPA also considers affordability, equity, and other factors when designing regulatory alternatives and when selecting particular alternatives as the basis for regulation.

[6] Recall from Section 2.6 that Executive Order 12291 specifies that EPA demonstrate (1) that net benefits of regulation are positive, and (2) that the selected regulatory alternative maximizes the net benefits. The Order also stipulates that net costs be minimized. In practice, this latter criterion cannot be considered unless there are at least two regulatory alternatives that maximize net benefits, the net benefits are identified, and they are fully quantified and monetized. Because EPA cannot quantify all the benefits, minimization of net costs is only of academic concern and is not considered in this regulatory impact analysis.

**Lack of Quantified C/E Criteria.** For some emissions—volatile organic compounds, $SO_2$, and PM—EPA has come up with ranges for social values of each Mg of emission reduction, and has used these dollars-per-Mg figures as C/E criteria to help in setting the stringency level for §111 regulations. (In one or two cases these social values have been less based on analysis than on somewhat arbitrary policy determinations made in an effort to maintain consistency in the regulatory process.) Unfortunately, with the Standards and Guidelines there are many pollutants for which there are no available dollars-per-Mg criteria. Development of each criterion requires years of research.

**Multiple Pollutants.** The Standards and Guidelines take aim at a bundle of pollutants. Materials separation and each APCD and GCP apply to several of these pollutants. A spray dryer–fabric filter combination, for example, will control acid gases, metals, and particulates. GCP will control most of the organics. $NO_X$ controls may affect mercury emissions. Possibly with the exception of materials separation, it is relatively easy to establish the cost of these controls, that is, the numerators of the C/E ratios. But what are the measures of effectiveness that go in the denominators? Where a §111 regulation is for the control of only one pollutant, it may be possible to find a denominator. Where there are several pollutants to be controlled, it is very difficult to calculate a denominator. Adding emission reductions of the various pollutants by weight is of no value, because equal weights of different pollutants often have dramatically different effects on health and welfare. The only theoretically defensible way to add the emission reductions is to add the *benefits* of the emission reductions. The problems with the benefits approach are reviewed in Chapter 12.

**Uncertain and Shifting Baseline.** The MWC industry currently is in a very dynamic growth phase, rendering the baseline uncertain. It has been very difficult for EPA to pin down an acceptable baseline against which initial incremental C/E ratios can be computed. Furthermore, the substitution analysis reveals that the stringency of the Standards, and probably also that of the Guidelines, will determine how many MWCs will be built and/or left operating over the next few years. The more stringent the regulations, the fewer will be the number of MWCs affected by the Standards and Guidelines, because to cut costs municipalities will return to, or will continue, landfilling their MSW.[7] This leads to a shifting baseline—one that is different for each regulatory alternative—in which C/E ratios behave unpredictably and generally are useless for selecting regulatory alternatives. With sufficient data and analytical effort this problem can be overcome. The numerators must be corrected to add in loss of what economists call the consumer surplus (something akin to the loss of the option to use MWCs that are closed or are not built), and the denominators must be corrected to account for emissions from landfilling (or recycling) MSW that otherwise would have been combusted.

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[7] EPA has not studied the question of whether materials separation requirements may place a disproportionate burden on certain types or sizes of MWCs, causing them to shut

**Multiple Pathways.** Achieving emission reductions from MWCs can be a mixed blessing, because much of what is pulled out of the stack goes into the ash. Normally, this is of no concern. However, for the Standards and Guidelines, the potential toxicity of fly ash and its potential pathway through ground water into water supply systems and the food chain is a problem. Thus, allowing emission reductions to stand alone in the denominator of a C/E ratio is not an altogether good way of measuring the beneficial effectiveness of an MWC regulatory alternative.

**Spatial and Temporal Patterns.** C/E ratios do not contain information on the spatial (stack height and locational) and temporal (hourly, daily, weekly, and seasonal) patterns of emissions and emissions reductions.

**All-Or-Nothing.** The economically optimal use of cost effectiveness is to help the economy reach a point where the last dollar spent on emission control returns just one dollar in effectiveness. Unfortunately, under §111 EPA must require emission standards based on the *best* available control technology (considering cost), or EPA *must issue no emission standards at all.* It is technically feasible to design most air pollution control devices for a range of costs and a matching range of effectiveness levels, and it *may* be legal to interpret the word "cost" as it appears in §111 as "cost effectiveness." Thus, it is conceivable that EPA could, if such action were indicated by application of C/E and other criteria, base emission standards on an APCD like fabric filters designed to remove only, say, 50 percent of the PM. However, in practice §111 is construed as precluding such a halfway approach because 50 percent removal is not up to what the *best* fabric filter can do. This attribute of §111 has many advantages, but in some situations such as with the Standards and Guidelines, it diminishes the potential utility of the C/E method for selecting a regulatory alternative.

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down or to not be built, and therefore may aggravate the "shifting baseline" problem described here.

### 6.3.3 Description of the Regulatory Alternatives

EPA selected five regulatory alternatives for use in evaluating a range of stringency levels for the Standards, and six regulatory alternatives for the Guidelines. The regulatory alternatives (see Tables 6.2 and 6.3), plus a regulatory baseline, reflect a range of control levels for MWC organics, MWC metals, and MWC acid gases.[8] For new MWCs, the baseline includes good combustion practices for all combustors with capacities greater than 45 Mg per day and PM control as required by Subparts Db and E. For existing MWCs, the baseline level of GCP and PM control varies by type, size, and age of combustor. In general, the regulatory alternatives increase in stringency from alternatives I to IV; however, alternative III is less stringent than IIB for small MWCs, and more stringent for large MWCs. The alternatives categorize MWCs into large and small combustors because (1) large combustors account for 90 percent of planned capacity (such that they have a larger emissions potential) and (2) control costs increase a small combustor's cost per Mg by a significantly larger factor. A third category for very large MWCs applies only to regulatory alternative IIB′ for the Guidelines. Small MWCs have capacities less than or equal to 225 Mg per day, and very large MWCs (in reference only to the Guidelines) have capacities above 2,000 Mg per day.

Regulatory alternatives for new MWCs are described first, followed by a discussion of differences between alternatives for new and existing MWCs.

Regulatory alternative I requires GCP and PM control to achieve reductions in MWC organics and PM for new MWCs. For small MWCs, this alternative effectively drops the lower size cutoff for PM emissions under Subpart E. The current emission limit of 180 mg/dscm, Subpart E, is required for all small MWCs. Large MWCs are required to achieve PM control to 34 mg/dscm. MWC organics are controlled to 500 ng/Nm$^3$. No emission reductions are required (or control costs incurred) for MWC metals and acid gases.

Regulatory alternative IIA requires more stringent control on new large MWCs than does I, but there is no change for new small MWCs. Beyond I, alternative IIA includes requirements for good acid gas controls (50 percent $SO_2$ and 80 percent HCl reduction) based on dry sorbent injection. MWC

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[8] EPA elected to handle materials separation and control of $NO_X$ outside this regulatory alternative structure.

**Table 6.2**: Regulatory Alternatives for the Standards For Combustion and Post-Combustion Control of MWC Emissions[a]

| Regulatory Alternative | MWC Plant Size[b]<br>Small<br>(≤225 Mg/D) | <br>Large<br>(>225 Mg/D) |
|---|---|---|
| I | GCP<br>Moderate PM | GCP<br>Best PM |
| II A | " " | GCP<br>Best PM<br>Good Acid Gas |
| II B | GCP<br>Best PM<br>Good Acid Gas | " " |
| III[c] | GCP<br>Moderate PM | GCP<br>Best PM<br>Best Acid Gas |
| IV | GCP<br>Best PM<br>Good Acid Gas | " " |

[a] Materials separation and control of $NO_X$ are not included in this regulatory alternative framework.

[b] This is the total capacity of all combustors at the plant site.

[c] This is the current operating guidance for new large MWCs.

*DEFINITIONS*: (See text for greater detail.)

GCP = Good combustion practice
Moderate PM = 182 mg/dscm maximum emission rate
Good PM = 69 mg/dscm maximum emission rate
Best PM = 34 mg/dscm maximum emission rate
Good acid gas = Use of dry sorbent injection
Best acid gas = Use of spray dryer and fabric filter

**Table 6.3**: Regulatory Alternatives for the Guidelines For Combustion and Post-Combustion Control of MWC Emissions[a]

| Regulatory Alternative | MWC Plant Size[b]<br>Small<br>($\leq$225 Mg/D) | <br>Large<br>(>225 Mg/D) |
|---|---|---|
| I | GCP<br>Moderate PM | GCP<br>Good PM |
| II A | " " | GCP<br>Good PM<br>Good Acid Gas |
| II B | GCP<br>Good PM<br>Good Acid Gas | " " |
| II B′ [c] | GCP<br>Moderate PM | GCP<br>Good/Best PM<br>Good/Best Acid Gas |
| III | GCP<br>Moderate PM | GCP<br>Best PM<br>Best Acid Gas |
| IV | GCP<br>Good PM<br>Good Acid Gas | " " |

[a] Materials separation and control of $NO_X$ are not included in this regulatory alternative framework.

[b] This is the total capacity of all combustors at the plant site.

[c] Large MWCs less than 2,000 Mg per day capacity must have good PM and acid gas control. Very large MWCs (greater than 2,000 Mg per day capacity) must have best PM and acid gas control.

*DEFINITIONS: See Table 6.2.*

organics are reduced to 75 ng/Nm$^3$.

Regulatory alternative IIB extends IIA to apply to small MWCs as well as large MWCs. All new MWCs are subject to GCP, PM control to 34 mg/dscm, and moderate acid gas controls (see IIA above). Again, MWC organics are controlled to 75 ng/Nm$^3$.

Regulatory alternative III is also similar to IIA. It has the same requirements for new small MWCs. New large MWCs, however, are required to achieve a more stringent level of acid gas control. Based on spray drying followed by a fabric filter, III requires the best control of acid gases (85 percent $SO_2$ and 95 percent HCl reduction). Regulatory alternative III, therefore, is more stringent than IIB for large MWCs and less stringent than IIB for small MWCs.

Regulatory alternative IV is the most stringent (lowest emissions and highest costs) alternative considered. It requires GCP and the best PM control on all new MWCs. The stringency of acid gas control varies by combustor size. Alternative IV requires the best control of acid gases for large MWCs (as in Alternative III) and good control for small MWCs (as in IIB).

For the Guidelines, the regulatory alternatives are structured in a similar manner. In most cases, where differences occur, the Guidelines alternatives are less stringent than those for the Standards. Regulatory alternatives I, IIA, and III for new and existing small (less than or equal to 225 Mg per day capacity) MWCs are the same. For large MWCs, Alternatives III and IV are the same for both new and existing MWCs.

What are the differences between the alternatives for new and existing combustors? Regulatory alternative I requires good, not the best, PM control on existing large MWCs. PM emissions are controlled to 69 mg/dscm based on an ESP upgrade.

Regulatory alternative IIA also requires good (not best) PM control for Guidelines MWCs, based on an ESP upgrade. Alternative IIA, however, also relaxes controls on MWC organics to 125 ng/Nm$^3$ and HCl to 50 percent reduction for existing large MWCs compared to the requirements for new large MWCs.

Regulatory alternative IIB, which is the same for existing small and large MWCs, is slightly less stringent for existing MWCs than it is for new combustors. Alternative IIB requires GCP, good PM control, moderate MWC organics control, and good acid gas control. Alternative IIB is an extension of IIA large MWC requirements to all existing MWCs.

Regulatory alternative IIB′ applies only to the Guidelines. It requires very large MWCs—those with capacities greater than 2,000 Mg per day—to install best PM and acid gas control. For large MWCs, IIB′ requires the same level of control as alternative IIB. For small MWCs, IIB′ requires the same level of control as alternative III which is less stringent than alternative IIB.

Regulatory alternative IV requires less stringent controls for existing small MWCs than for new small MWCs. For existing small MWCs, IV requires the same level of control as alternative IIB.

# Chapter 7

# Municipal Waste Combustor Characteristics and Control Costs

## 7.1 Characteristics

Combustion was once a principal way of disposing of MSW in metropolitan areas of the U.S. These MWCs, along with many burning dumps, were dirty, and virtually all were closed in the two decades following World War II. A renewed interest in the technology, coincident with reductions in available, convenient landfill capacity and the search for alternative energy sources, occurred in the mid-1970s. In the early and mid-1980s, new MWC capacity was added rapidly. The amount of waste combusted increased by a factor of three or four from 1980 to 1986, and MWCs took on the characteristics that we observe today.

### 7.1.1 A Basic Classification of MWCs

There are three principal types of MWCs: mass burn, modular, and refuse-derived fuel (RDF) combustors. A fourth type, combustors that employ fluidized-bed combustion (FBC), is less common. There are variations within these categories, and there are designs that incorporate features of more than one type. Regardless of the technology, each MWC plant site has one, or most likely more than one, individual component combustor.

Some air pollution control devices (APCDs) control emissions from individual components, while others control emissions from all components on the site.

Mass burn combustors are field-erected and span a wide size range. Individual combustors range in capacity from 45 to 900 Mg MSW combusted per day. There are typically two or three individual combustors per plant site, and plant capacities range from about 90 to 2,700 Mg MSW per day. The technology is called mass burn because the waste is burned without any processing other than removal of bulky noncombustible material and items too large to squeeze through the entrance to the combustion chamber. In addition to size, wall and grate design define the types of mass burn combustors. Essentially all new mass burn combustors will have waterwalls for energy recovery. Some older mass burn combustors have refractory-lined walls without any energy recovery.

Modular combustors also burn waste without much processing, but are usually shop-fabricated. Components range in capacity from 5 to 110 Mg MSW per day. There are typically one to four or more individual combustors per plant site, and plant capacities typically range from about 15 to 360 Mg MSW per day. Generally, modular units are dual-chambered combustors. Depending on the design, the volume of combustion air supplied to the primary chamber either is greater than the amount needed for complete combustion—these are called modular excess air MWCs—or less than the amount needed for complete combustion—these are modular starved air MWCs. A secondary combustion chamber is used after the primary chamber to complete the combustion process. Although many existing modular combustors do not have energy recovery, the majority of new modular combustors will incorporate energy recovery.

RDF combustors burn processed and shredded MSW. The degree of processing varies from simple removal of bulky items accompanied by shredding of the remaining waste, to removal of most noncombustible material and processing of the residue into fine particles. The sorting and separating typically is accomplished by a process line of shredders, magnets, screens, and air classifiers. The resulting RDF has a higher energy value and lower ash content than less-processed MSW, and it burns more completely. Some RDF MWCs are designed to combust only RDF, while others combust a mixture of RDF and other fuel such as wood or coal. Most RDF components range in capacity from 270 to 900 Mg MSW per day. Plants typically have two to four combustors, and plants handle from 550 to 3,600 Mg MSW per day.

The last class of MWCs is combustors employing FBC. In FBC, the RDF, sometimes mixed with other fuels, burns in a turbulent bed of heated noncombustible material, generally sand or limestone. There are two basic designs: bubbling-bed and circulating-bed. The former operates with relatively low turbulence to minimize entrainment of solids in the flue gas. The latter operates with relatively high turbulence and employs a cyclone separator to capture and return unburned and inert particles to the bed. By making the waste behave as a liquid or gas, FBC ensures good fuel mixing, good heat transfer, and efficient combustion. At present, however, application of the technology to MWCs is relatively new. Typical FBC component combustor capacities for planned units are 180 to 450 Mg MSW per day, and total plant capacities range from 270 to 900 Mg MSW per day.

### 7.1.2 Ash Handling

Municipal waste combustors decrease the volume of municipal solid waste by 70 to 90 percent. The remaining waste, MWC ash, consists of bottom ash from the combustion chamber and fly ash from the stack gas. At most existing MWC sites, the two types of ash are combined prior to disposal. Historically, disposing of MWC ash (like its precursor MSW) means landfilling.

The potential toxicity of MWC ash is a cause of public concern. This ash contains varying quantities of toxic materials including lead, mercury, and cadmium, which are concentrated in the fly ash. These MWC metals condense on the fly ash particles and are collected by the APCD. These toxic materials may leach into ground and surface water supplies through inadequate disposal of MWC ash. Human exposure to the toxic constituents of the MWC ash also can be through airborne particles. The culprit is windblown ash dust at the combustor site or the landfill, and in transit from the combustor to the landfill.

Current ash management is regulated by the EPA under RCRA, which is directed at solid wastes in general and not specially at MWC ash. RCRA classifies solid wastes as either hazardous or nonhazardous based on four characteristics: corrosiveness, ignitability, reactiveness, and toxicity. The results of toxicity tests on selected samples of MWC ash are mixed. Some samples indicate toxicity and others do not. Furthermore, the results of tests on the same samples are not always reproducible.

Because of the uncertainties surrounding the toxicity of MWC ash and the RCRA language pertaining to a household waste exclusion, MWC ash is typically managed and disposed of as a nonhazardous waste. While the majority of existing landfills are unlined, it is likely that disposal of MWC ash in lined landfills will be required by environmental legislation. Several bills are being considered during the 101st Congress that would classify MWC ash as nonhazardous, while requiring special handling provisions such as disposal in lined landfills. The bills impose less costly requirements for disposal of MWC ash in monofills where MWC ash is not commingled with other MSW.

The technology debate focuses on the level of leachate containment controls and groundwater monitoring requirements. Reliable leachate data are needed to provide a scientific basis for the containment debate. Again, reproducibility is a problem. Improvements in the testing methods may help; however, the high variability in the composition of MWC ash and the difficulty in duplicating actual long-term conditions will continue to complicate the gathering of reliable data. The debate may be settled on legislative rather than purely scientific grounds.

Other strategies are based on reducing the toxicity of the MWC ash. This can be accomplished through the removal of problem materials prior to combustion, or the post-combustion extraction or stabilization of toxic residues. Productive use of detoxified MWC ash holds promise as a partial solution to disposal. In Europe MWC ash is used for construction fill, concrete blocks, and road beds. The concentration of toxic constituents is reduced by the current practice of combining bottom ash and fly ash. This practice, however, creates a larger volume of contaminated waste while doing nothing to reduce the amount of toxic metals and organics.

### 7.1.3 Model Plants

To analyze the impacts of alternative regulations, and to help select the appropriate level of stringency for regulations, EPA creates "model plants" that are prototypes of the plants or facilities that will be regulated. See

Table 7.1. For the development of the Standards, 12 model plants are defined, and for the Guidelines, 17. Combustion technology is advancing so rapidly that it has not been possible to use the same set of model plants for both the Standards and the Guidelines. The "transitional" prefix to some Guidelines model plant titles indicates that the model plants have more advanced design and air pollution control than do others of the same types.

### 7.1.4 Model Plant Throughput

Table 7.2 gives throughput data for the model plants. (Data in this and most other tables in this document are rounded results of calculations using unrounded inputs.) Design capacity (second column) normally is expressed as a daily rate for combustion of MSW. All combustors, regardless of type, operate at or close to their maximum design rate for the hours or days they are burning MSW. The daily capacity figure also represents the amount of MSW received at the MWC; in the economic analysis no allowance is made for removal of noncombustible material and items too large to fit in the combustor, items that cannot be processed into RDF, or items to be recycled.[1] The annual hours of operation (third column) are based on recent industry experience in capacity utilization. (The special conditions referred to in note *a* reflect increased downtime for some old plants and some small plants, and allowances for stand-by units and the co-firing of other materials.) In 1988, capacity utilization, which may be thought of as the percent of days a plant or combustor operates, averaged

- Mass burn: 85 percent,
- RDF and FBC: 83 percent, and
- Modular: 82 percent.

These rates are expected to continue into the near future. Thus, each entry in the third column of Table 7.2 is the total number of hours in a year (8,760)

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[1] An RDF MWC with the same combustion capacity as a mass burn MWC may accept more MSW than the mass burn MWC. This is because a larger share of the RDF plant's input is separated out for recycling or landfilling. It is possible to calculate all MWC emission factors on the basis of MSW received rather than combusted. However, this is not done here because too little is known about the amount and destination of the separated items, and what air pollution they ultimately generate if landfilled.

Table 7.1: Model Plants for the Standards and Guidelines

| Model Plant | Abbreviation | Description |
|---|---|---|
| | **Standards** | |
| 1 | MB/WW (small) | Mass burn waterwall, small |
| 2 | MB/WW (mid-size) | Mass burn waterwall, mid-size |
| 3 | MB/WW (large) | Mass burn waterwall, large |
| 4 | MB/REF | Mass burn refactory wall |
| 5 | MB/RC | Mass burn rotary combustor |
| 6 | RDF | Refuse-derived fuel |
| 7 | RDF/CF | Refuse-derived fuel, co-fired |
| 8 | MOD/EA | Modular excess air |
| 9 | MOD/SA (small) | Modular starved air, small |
| 10 | MOD/SA (mid-size) | Modular starved air, mid-size |
| 11 | FBC/CB | Fluidized bed combustion, circulating bed |
| 12 | FBC/BB | Fluidized bed combustion, bubbling bed |
| | **Guidelines** | |
| 1 | MB/REF/TG | Mass burn refactory wall traveling grate |
| 2 | MB/REF/RG | Mass burn refactory wall rocking grate |
| 3 | MB/REF/RK | Mass burn refactory wall rotary kiln |
| 4 | MB/WW (large) | Mass burn waterwall, large |
| 5 | MB/WW (mid-size) | Mass burn waterwall, mid-size |
| 6 | MB/WW (small) | Mass burn waterwall, small |
| 7 | RDF (large) | Refuse-derived fuel, large |
| 8 | RDF (small) | Refuse-derived fuel, small |
| 9 | MOD/SA/TR | Modular starved air, transfer rams |
| 10 | MOD/SA/G | Modular starved air, grates |
| 11 | MOD/EA | Modular excess air |
| 12 | MB/RWW | Mass burn rotary waterwall |
| 13 | TRANS MOD/EA | Transitional modular excess air |
| 14 | TRANS MB/WW | Transitional mass burn waterwall |
| 15 | TRANS RDF (large) | Transitional refuse-derived fuel, large |
| 16 | TRANS RDF (small) | Transitional refuse-derived fuel, small |
| 17 | TRANS MB/RWW | Transitional mass burn rotary waterwall |

**Table 7.2**: Baseline Model Plant Throughput

| Model Plant | Daily Capacity (Mg/day) | Annual Hours in Operation (Hours/year) | Annual MSW Combusted (Mg/year) | Ash Output (Mg/year) |
|---|---|---|---|---|
| **Standards** | | | | |
| 1 | 180 | 5,000[a] | 37,800 | 12,100 |
| 2 | 730 | 7,420 | 224,000 | 71,600 |
| 3 | 2,040 | 7,420 | 631,000 | 201,000 |
| 4 | 450 | 7,420 | 140,000 | 44,700 |
| 5 | 950 | 7,420 | 294,000 | 94,000 |
| 6 | 1,810 | 7,250 | 548,000 | 80,900 |
| 7 | 1,810 | 3,620[a] | 274,000 | 77,900 |
| 8 | 220 | 7,160 | 64,900 | 20,700 |
| 9 | 45 | 5,000[a] | 9,450 | 2,840 |
| 10 | 90 | 7,160 | 27,000 | 8,120 |
| 11 | 820 | 7,270 | 247,000 | 18,700 |
| 12 | 820 | 7,270 | 247,000 | 18,700 |
| **Guidelines** | | | | |
| 1 | 680 | 6,500[a] | 184,000 | 92,300 |
| 2 | 220 | 6,200[a] | 56,800 | 19,200 |
| 3 | 820 | 7,420 | 254,000 | 75,900 |
| 4 | 2,040 | 7,420 | 631,000 | 202,000 |
| 5 | 980 | 7,420 | 303,000 | 91,100 |
| 6 | 180 | 7,420 | 55,700 | 17,900 |
| 7 | 1,810 | 7,250 | 546,000 | 81,100 |
| 8 | 540 | 7,250 | 163,000 | 16,500 |
| 9 | 140 | 4,770[a] | 27,800 | 8,140 |
| 10 | 45 | 6,500[a] | 12,200 | 6,690 |
| 11 | 180 | 7,160 | 53,700 | 16,300 |
| 12 | 450 | 7,420 | 139,000 | 42,200 |
| 13 | 380 | 7,160 | 113,000 | 36,300 |
| 14 | 180 | 7,420 | 55,700 | 17,900 |
| 15 | 1,810 | 7,250 | 546,000 | 81,100 |
| 16 | 540 | 7,250 | 163,000 | 16,500 |
| 17 | 450 | 7,420 | 139,000 | 42,200 |

See text for an explanation of this table.

[a] These values reflect special conditions.

multiplied by the capacity utilization percentage, and rounded. The annual MSW combusted (fourth column) is the daily capacity divided by 24 and multiplied by the annual hours of operation, and rounded. The last column gives the ash output, which includes some residual quench water. These throughput data are used in subsequent chapters, along with throughputs based on higher alternative rates that reflect more optimum conditions, to project the impacts of regulatory action.

## 7.2 Control Costs

Tables 7.3 and 7.4 list the estimated baseline capital and annual operating costs and annual energy recovery revenues for the model plants. Baseline costs provide a perspective for evaluating the costs of the regulatory alternatives. Total annual costs for publicly and privately owned plants are presented less the revenues for energy recovery. Capital costs are annualized at 4 percent for publicly owned plants and 8 percent for privately owned plants. Tables 7.3 and 7.4 differ in the presentation of costs: dollars per year versus dollars per Mg of MSW combusted, respectively.

The dollars-per-Mg values[2] can be used to compare public and private ownership. The values indicate what an MWC must receive per Mg of MSW to cover combustion or control costs. Model plants with higher capital cost components shift the cost comparison in favor of public ownership. For the 12 model plants analyzed for the Standards, the baseline cost per Mg is 0.2 to 434 percent higher for private ownership. The cost of control for the same model plants is 12 to 43 percent higher for private ownership. These results, however, do not reflect sectorial differences in productivity. Nor do the results reflect variation in financial parameters within the public sector and private sector. The actual financial parameters may, in fact, overlap over some range of values. Nonetheless, these data support the contention that publicly owned MWCs will become the norm. Therefore, the cost impacts of the Standards and of the Guidelines are based in this regulatory impact analysis on public ownership.

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[2] The terminology "$/Mg" or "cost per Mg" is somewhat awkward. A simpler term, "unit cost," is not used because in another context it means the cost associated with an individual combustor at an MWC plant site with several combustors.

Table 7.5 lists by model plant and regulatory alternative the estimated enterprise[3] costs for the Standards. Table 7.6 gives the same information for the Guidelines.[4] The enterprise costs are the actual costs faced by the plant in complying with the Standards or the Guidelines. The capital and annual operating cost components are zero if the MWC plant qualifies for an exemption from regulation beyond baseline. Capital costs for APCDs are annualized over a 15 year equipment life. Total annual costs divided by model plant throughputs, costs per Mg, provide a good basis for comparing regulatory alternatives. Note that regulatory stringency and costs per Mg do not increase in going from alternatives IIB to III for some model plants.

Under the Standards, capital costs for APCDs range from zero (for some small MWCs) to \$19.7 million (for large RDFs under alternatives III and IV). Annual operating costs for environmental controls range from zero to \$3.6 million. Similarly, capital costs under the Guidelines range from zero to \$53.6 million. Annual operating costs range from zero to \$5.1 million.

Table 7.7 lists the percent increase, over baseline, in model plant costs per Mg for each regulatory alternative for both new MWCs and existing MWCs. In general the percent increase over baseline is higher for existing MWCs, because of lower baseline costs, than for new combustors of equivalent size. Excluding RDF, the percent increase under the Standards ranges from zero to 83 percent. RDF costs increase by 200 to 275 percent for alternatives beyond regulatory alternative I. Under the Guidelines annual costs per Mg increase by zero to 175 percent typically, however, some model plants show percent increases in the 300 to 520 range.

Tables 7.5, 7.6, and 7.7 do not include costs for materials separation, $NO_X$ control, and Guidelines regulatory alternative IIB′. The cost of materials separation and revenue from recycling probably will balance one another in the long run for both new and existing plants. $NO_X$ controls apply to new MWCs only. Capital costs for $NO_X$ range from \$616,000 to \$3.7 million per model plant. Total annual costs range from \$190,000 to \$1.2 million per model plant, or from \$1.70 to \$3.60 per Mg of MSW combusted. Costs for alternative IIB′ are those shown for IIB in Table 7.6 except model plant 4 which has the costs shown for alternative III and model plants 2, 6, 9, 10, 11 and 14 which have costs shown for IIA.

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[3] Enterprise costs of regulation are costs experienced by each MWC. In Chapter 10 enterprise costs are compared with social costs, which are costs of regulation experienced by society as a whole. See page xv and Sections 9.3, 10.1 and 10.2 for more explanation of the cost terminology.

[4] EPA has not estimated all costs of regulation. See Section 10.5.

**Table 7.3**: Baseline Model Plant Costs and Energy Revenue
(1987 $ per Year)

| Model Plant | ------ Cost ------ | | Annual Energy Recovery Revenue ($\$10^3$/yr) | Annualized Capital Plus Annual Operating Costs Net of Energy Revenue | |
|---|---|---|---|---|---|
| | Initial Capital ($\$10^3$) | Annual Operating ($\$10^3$/yr) | | Private MWC ($\$10^3$/yr) | Public MWC ($\$10^3$/yr) |
| | | | **Standards** | | |
| 1 | 19,700 | 2,680 | 1,040 | 4,260 | 2,850 |
| 2 | 53,200 | 7,610 | 6,160 | 8,580 | 4,640 |
| 3 | 117,000 | 16,200 | 17,300 | 14,300 | 5,930 |
| 4 | 40,400 | 6,750 | 3,020 | 9,360 | 6,170 |
| 5 | 73,300 | 10,200 | 8,310 | 11,700 | 6,260 |
| 6 | 143,000 | 15,300 | 21,800 | 11,600 | 1,961 |
| 7 | 152,000 | 15,900 | 24,200 | 10,700 | 4,850 |
| 8 | 14,500 | 2,490 | 1,400 | 3,140 | 1,980 |
| 9 | 1,270 | 439 | 0 | 605 | 512 |
| 10 | 5,880 | 1,050 | 582 | 1,310 | 845 |
| 11 | 73,900 | 8,720 | 9,860 | 8,460 | 3,250 |
| 12 | 73,900 | 8,720 | 9,860 | 8,460 | 3,250 |
| | | | **Guidelines** | | |
| 1 | — | 8,550 | 0 | 8,550 | |
| 2 | — | 3,560 | 0 | 3,560 | |
| 3 | — | 9,910 | 0 | 9,910 | |
| 4 | — | 16,500 | 17,300 | -1,980 | |
| 5 | — | 10,600 | 8,290 | 1,540 | |
| 6 | — | 3,130 | 1,540 | 1,370 | |
| 7 | — | 12,200 | 21,800 | -10,800 | |
| 8 | — | 6,340 | 6,550 | -812 | |
| 9 | — | 1,130 | 873 | 140 | |
| 10 | — | 292 | 0 | 292 | |
| 11 | — | 1,510 | 1,160 | 183 | |
| 12 | — | 5,720 | 3,840 | 1,470 | |
| 13 | — | 4,540 | 2,440 | 1,620 | |
| 14 | — | 3,130 | 1,540 | 1,370 | |
| 15 | — | 32,700 | 21,800 | 7,780 | |
| 16 | — | 12,200 | 6,550 | 4,500 | |
| 17 | — | 5,720 | 3,840 | 1,470 | |

See text for an explanation of this table.

**Table 7.4**: Baseline Model Plant Costs and Energy Revenue
(1987 $ per Mg MSW Combusted)

|  | ------ Cost ------ |  | Annual Energy Recovery Revenue | Annualized Capital Plus Annual Operating Costs Net of Energy Revenue |  |
|---|---|---|---|---|---|
| Model Plant | Initial Capital ($\$10^3$) | Annual Operating ($/Mg) | ($/Mg) | Private MWC ($/Mg) | Public MWC ($/Mg) |
|  | **Standards** |  |  |  |  |
| 1 | 19,700 | 71.00 | 27.40 | 113.00 | 75.40 |
| 2 | 53,200 | 33.90 | 27.50 | 35.50 | 20.70 |
| 3 | 117,000 | 25.70 | 27.40 | 21.00 | 9.40 |
| 4 | 40,400 | 48.10 | 21.50 | 61.90 | 44.00 |
| 5 | 73,300 | 34.60 | 28.20 | 36.80 | 21.30 |
| 6 | 143,000 | 27.90 | 39.90 | 19.11 | 3.58 |
| 7 | 152,000 | 29.00 | 44.20 | 17.75 | 17.70 |
| 8 | 14,500 | 38.40 | 21.50 | 43.30 | 30.40 |
| 9 | 1,270 | 46.50 | 0 | 64.00 | 54.20 |
| 10 | 5,880 | 38.60 | 21.50 | 43.40 | 31.20 |
| 11 | 73,900 | 35.20 | 39.90 | 31.10 | 13.20 |
| 12 | 73,900 | 35.20 | 39.90 | 31.10 | 13.20 |
|  | **Guidelines** |  |  |  |  |
| 1 | — | 46.40 | 0 | 46.40 |  |
| 2 | — | 63.30 | 0 | 63.30 |  |
| 3 | — | 36.40 | 0 | 36.40 |  |
| 4 | — | 24.20 | 27.40 | -3.13 |  |
| 5 | — | 32.50 | 27.40 | 5.08 |  |
| 6 | — | 51.90 | 27.60 | 24.40 |  |
| 7 | — | 20.30 | 40.00 | -19.70 |  |
| 8 | — | 35.20 | 40.20 | -4.94 |  |
| 9 | — | 24.40 | 19.20 | 4.17 |  |
| 10 | — | 23.80 | 0 | 23.80 |  |
| 11 | — | 25.10 | 21.70 | 3.39 |  |
| 12 | — | 37.80 | 27.60 | 10.50 |  |
| 13 | — | 35.80 | 21.60 | 14.20 |  |
| 14 | — | 51.90 | 27.60 | 24.40 |  |
| 15 | — | 54.00 | 40.00 | 14.20 |  |
| 16 | — | 67.60 | 40.20 | 27.40 |  |
| 17 | — | 37.80 | 27.60 | 10.50 |  |

See text for an explanation of this table.

**Table 7.5**: Model Plant Control Costs for the Standards (Enterprise Costs for Publicly Owned Plants, 1987 $)[a]

| Model Plant | Capital Costs[b] ($\$10^3$) | Annual Operating Costs[c] ($\$10^3$/yr) | Total Annual Costs[d] ($\$10^3$/yr) | Annual Costs per Mg MSW[e] ($/Mg) |
|---|---|---|---|---|
| - - - - - - - - - - **Regulatory Alternative I** - - - - - - - - - - | | | | |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 480 | 39.0 | 82.0 | 0.37 |
| 3 | 1,350 | 114 | 236 | 0.37 |
| 4 | 620 | 50.0 | 106 | 0.75 |
| 5 | 540 | 35.2 | 84.0 | 0.28 |
| 6 | 1,240 | 109 | 220 | 0.40 |
| 7 | 1,240 | 49.8 | 161 | 0.59 |
| 8 | 0 | 0 | 0 | 0 |
| 9 | 532 | 72.0 | 120 | 12.70 |
| 10 | 0 | 0 | 0 | 0 |
| 11 | 0 | 0 | 0 | 0 |
| 12 | 0 | 0 | 0 | 0 |
| - - - - - - - - - **Regulatory Alternative IIA** - - - - - - - - - | | | | |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 3,370 | 1,260 | 1,560 | 6.97 |
| 3 | 7,830 | 2,890 | 3,600 | 5.69 |
| 4 | 2,780 | 1,070 | 1,320 | 9.38 |
| 5 | 3,820 | 1,640 | 1,990 | 6.75 |
| 6 | 7,660 | 3,250 | 3,940 | 7.20 |
| 7 | 7,660 | 1,290 | 1,980 | 7.25 |
| 8 | 0 | 0 | 0 | 0 |
| 9 | 532 | 72.0 | 120 | 12.70 |
| 10 | 0 | 0 | 0 | 0 |
| 11 | 450 | 919 | 959 | 0 |
| 12 | 450 | 1,520 | 1,560 | 0 |

See notes at end of table.

**Table 7.5:** Model Plant Control Costs for the Standards (Continued)

| Model Plant | Capital Costs[b] (\$10$^3$) | Annual Operating Costs[c] (\$10$^3$/yr) | Total Annual Costs[d] (\$10$^3$/yr) | Annual Costs per Mg MSW[e] (\$/Mg) |
|---|---|---|---|---|
| - - - - - - - - - - **Regulatory Alternative IIB** - - - - - - - - - - | | | | |
| 1 | 1,100 | 540 | 639 | 16.90 |
| 2 | 3,370 | 1,260 | 1,560 | 6.97 |
| 3 | 7,830 | 2,890 | 3,590 | 5.69 |
| 4 | 2,780 | 1,070 | 1,320 | 9.38 |
| 5 | 3,820 | 1,640 | 1,990 | 6.75 |
| 6 | 7,660 | 3,250 | 3,940 | 7.20 |
| 7 | 7,660 | 1,290 | 1,980 | 7.25 |
| 8 | 1,260 | 460 | 573 | 8.83 |
| 9 | 1,400 | 322 | 448 | 47.40 |
| 10 | 1,260 | 347 | 460 | 17.00 |
| 11 | 450 | 919 | 959 | 3.88 |
| 12 | 450 | 1,520 | 1,560 | 6.30 |
| - - - - - - - - - **Regulatory Alternative III** - - - - - - - - - | | | | |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 8,870 | 1,450 | 2,250 | 10.00 |
| 3 | 18,300 | 3,260 | 4,910 | 7.78 |
| 4 | 8,820 | 1,310 | 2,100 | 15.00 |
| 5 | 11,500 | 1,900 | 2,940 | 9.97 |
| 6 | 19,700 | 3,630 | 5,400 | 9.86 |
| 7 | 19,700 | 1,480 | 3,240 | 11.90 |
| 8 | 0 | 0 | 0 | 0 |
| 9 | 532 | 72 .0 | 120 | 12.69 |
| 10 | 0 | 0 | 0 | 0 |
| 11 | 8,560 | 1,340 | 2,110 | 8.54 |
| 12 | 8,560 | 1,340 | 2,110 | 8.54 |

See notes at end of table.

**Table 7.5:** Model Plant Control Costs for the Standards (Concluded)

| Model Plant | Capital Costs[b] ($\$10^3$) | Annual Operating Costs[c] ($\$10^3$/yr) | Total Annual Costs[d] ($\$10^3$/yr) | Annual Costs per Mg MSW[e] (\$/Mg) |
|---|---|---|---|---|
| - - - - - - - - - - **Regulatory Alternative IV** - - - - - - - - - - | | | | |
| 1 | 1,100 | 540 | 639 | 16.90 |
| 2 | 8,870 | 1,450 | 2,250 | 10.00 |
| 3 | 18,300 | 3,260 | 4,910 | 7.78 |
| 4 | 8,820 | 1,310 | 2,100 | 15.00 |
| 5 | 11,500 | 1,900 | 2,940 | 9.97 |
| 6 | 19,700 | 3,630 | 5,400 | 9.86 |
| 7 | 19,700 | 1,480 | 3,240 | 11.90 |
| 8 | 1,260 | 460 | 573 | 8.83 |
| 9 | 1,400 | 322 | 448 | 47.40 |
| 10 | 1,260 | 347 | 460 | 17.00 |
| 11 | 8,560 | 1,340 | 2,110 | 8.54 |
| 12 | 8,560 | 1,340 | 2,110 | 8.54 |

[a] Control costs are costs over the baseline model plant costs. Control costs are incurred to meet the emission requirements of the Standards. Materials separation and $NO_X$ control costs are not included in this table. Materials separation costs are expected to be negligible in the long run for the average MWC. $NO_X$ costs will affect only model plants 2 through 7, 11, and 12. Capital costs for $NO_X$ range from \$616,000 to \$3.7 million per model plant. Total annual costs range from \$190,000 to \$1.2 million per model plant, or from \$1.70 to \$3.60 per Mg of MSW combusted.

[b] Capital costs are for one APCD lifetime of 15 years and are untouched by discounting procedures.

[c] Annual operating costs are assumed to be constant from year to year.

[d] Total annual costs are annual operating costs plus capital costs annualized at 4 percent.

[e] Annual costs per Mg are costs from the preceding column divided by the annual throughput from Table 7.2.

**Table 7.6**: Model Plant Control Costs for the Guidelines
(Enterprise Costs For Publicly Owned Plants, 1987 \$)[a]

| Model Plant | Capital Costs[b] (\$10³) | Annual Operating Costs[c] (\$10³/yr) | Total Annual Costs[d] (\$10³/yr) | Annual Costs per Mg MSW[e] (\$/Mg) |
|---|---|---|---|---|
| - - - - - - - - - - - - - **Regulatory Alternative I** - - - - - - - - - - - - - | | | | |
| 1 | 16,000 | -190 | 1,250 | 6.80 |
| 2 | 5,850 | 461 | 987 | 17.60 |
| 3 | 1,240 | 246 | 358 | 1.42 |
| 4 | 5,540 | 288 | 787 | 1.25 |
| 5 | 86 | 127 | 135 | 0.45 |
| 6 | 991 | 186 | 275 | 4.90 |
| 7 | 10,900 | 235 | 1,210 | 2.21 |
| 8 | 4,330 | 168 | 557 | 3.39 |
| 9 | 270 | 131 | 155 | 5.73 |
| 10 | 716 | 171 | 235 | 19.20 |
| 11 | 0 | 0 | 0 | 0 |
| 12 | 2,880 | 121 | 379 | 2.71 |
| 13 | 1,830 | 76 | 241 | 2.12 |
| 14 | 0 | 0 | 0 | 0 |
| 15 | 0 | 0 | 0 | 0 |
| 16 | 0 | 0 | 0 | 0 |
| 17 | 2,850 | 136 | 368 | 2.63 |
| - - - - - - - - - - - - **Regulatory Alternative IIA** - - - - - - - - - - - - | | | | |
| 1 | 18,500 | 580 | 2,250 | 12.20 |
| 2 | 5,850 | 461 | 987 | 17.60 |
| 3 | 8,820 | 1,580 | 2,370 | 9.39 |
| 4 | 10,500 | 2,240 | 3,190 | 5.05 |
| 5 | 8,160 | 1,540 | 2,270 | 7.51 |
| 6 | 991 | 186 | 275 | 4.90 |
| 7 | 16,400 | 1,980 | 3,450 | 6.31 |
| 8 | 11,000 | 1,200 | 2,190 | 13.30 |
| 9 | 270 | 131 | 155 | 5.73 |
| 10 | 716 | 171 | 235 | 19.20 |
| 11 | 0 | 0 | 0 | 0 |
| 12 | 5,030 | 825 | 1,280 | 9.11 |
| 13 | 3,200 | 515 | 805 | 7.09 |
| 14 | 0 | 0 | 0 | 0 |
| 15 | 5,500 | 1,870 | 2,360 | 4.31 |
| 16 | 6,090 | 1,160 | 1,610 | 9.78 |
| 17 | 4,730 | 842 | 1,270 | 9.04 |

See notes at end of table.

**Table 7.6:** Model Plant Control Costs for the Guidelines (Continued)

| Model Plant | Capital Costs[b] ($\$10^3$) | Annual Operating Costs[c] ($\$10^3$/yr) | Total Annual Costs[d] ($\$10^3$/yr) | Annual Costs per Mg MSW[e] ($/Mg) |
|---|---|---|---|---|
| **- - - - - - - - - - - - - Regulatory Alternative IIB - - - - - - - - - - - - -** | | | | |
| 1 | 18,500 | 580 | 2,250 | 12.20 |
| 2 | 7,560 | 1,010 | 1,690 | 30.00 |
| 3 | 8,820 | 1,580 | 2,370 | 9.39 |
| 4 | 10,500 | 2,240 | 3,190 | 5.05 |
| 5 | 8,160 | 1,540 | 2,270 | 7.51 |
| 6 | 4,540 | 786 | 1,190 | 21.30 |
| 7 | 16,400 | 1,980 | 3,450 | 6.31 |
| 8 | 11,000 | 1,200 | 2,190 | 13.30 |
| 9 | 2,870 | 468 | 727 | 26.90 |
| 10 | 1,570 | 452 | 593 | 48.30 |
| 11 | 2,280 | 363 | 568 | 10.50 |
| 12 | 5,030 | 825 | 1,280 | 9.11 |
| 13 | 3,220 | 515 | 805 | 7.09 |
| 14 | 4,050 | 676 | 1,040 | 18.50 |
| 15 | 5,500 | 1,870 | 2,360 | 4.31 |
| 16 | 6,090 | 1,160 | 1,610 | 9.78 |
| 17 | 4,730 | 842 | 1,270 | 9.04 |
| **- - - - - - - - - - - - Regulatory Alternative III - - - - - - - - - - - -** | | | | |
| 1 | 34,150 | 2,090 | 5,160 | 28.00 |
| 2 | 5,850 | 461 | 987 | 17.60 |
| 3 | 31,040 | 3,660 | 6,460 | 25.60 |
| 4 | 36,750 | 4,740 | 8,050 | 12.80 |
| 5 | 22,400 | 2,940 | 4,960 | 16.40 |
| 6 | 991 | 186 | 275 | 4.90 |
| 7 | 53,600 | 5,050 | 9,870 | 18.00 |
| 8 | 24,200 | 2,270 | 4,450 | 27.10 |
| 9 | 270 | 131 | 155 | 5.73 |
| 10 | 716 | 171 | 235 | 19.20 |
| 11 | 0 | 0 | 0 | 0 |
| 12 | 11,500 | 1,470 | 2,500 | 17.80 |
| 13 | 7,380 | 939 | 1,600 | 14.10 |
| 14 | 0 | 0 | 0 | 0 |
| 15 | 29,500 | 4,620 | 7,270 | 13.30 |
| 16 | 15,100 | 2,000 | 3,340 | 20.40 |
| 17 | 11,200 | 1,460 | 2,460 | 17.60 |

See notes at end of table.

**Table 7.6**: Model Plant Control Costs for the Guidelines (Concluded)

| Model Plant | Capital Costs[b] ($$10^3$) | Annual Operating Costs[c] ($$10^3$/yr) | Total Annual Costs[d] ($$10^3$/yr) | Annual Costs per Mg MSW[e] ($/Mg) |
|---|---|---|---|---|
| **Regulatory Alternative IV** | | | | |
| 1 | 34,100 | 2,090 | 5,160 | 28.00 |
| 2 | 7,560 | 1,010 | 1,690 | 30.00 |
| 3 | 31,000 | 3,660 | 6,460 | 25.60 |
| 4 | 36,800 | 4,740 | 8,050 | 12.80 |
| 5 | 22,400 | 2,940 | 4,950 | 16.40 |
| 6 | 4,500 | 787 | 1,190 | 21.30 |
| 7 | 53,600 | 5,050 | 9,870 | 18.00 |
| 8 | 24,200 | 2,270 | 4,450 | 27.10 |
| 9 | 2,870 | 468 | 727 | 26.90 |
| 10 | 1,570 | 452 | 593 | 48.30 |
| 11 | 2,280 | 363 | 568 | 10.50 |
| 12 | 11,500 | 1,470 | 2,500 | 17.80 |
| 13 | 7,380 | 939 | 1,600 | 14.10 |
| 14 | 4,050 | 676 | 1,040 | 18.50 |
| 15 | 29,500 | 4,620 | 7,270 | 13.30 |
| 16 | 15,800 | 2,000 | 3,340 | 20.40 |
| 17 | 11,200 | 1,460 | 2,460 | 17.60 |

[a] Control costs are costs over the baseline model plant costs. Control costs are incurred to meet the emission requirements of the Guidelines. Materials separation and regulatory alternative IIB′ control costs are not included in this table. Materials separation costs are expected to be negligible in the long run for the average MWC. Costs for regulatory alternative IIB′ are those shown for IIB except that model plant 4 has the costs shown for regulatory alternative III and model plants 2, 6, 9, 10, 11 and 14 have the costs shown for regulatory alternative IIA.

[b] Capital costs are for one APCD lifetime of 15 years and are untouched by discounting procedures.

[c] Annual operating costs are assumed to be constant from year to year.

[d] Total annual costs are annual operating costs plus capital costs annualized at 4 percent.

[e] Annual costs per Mg are costs from the preceding column divided by the annual throughput from Table 7.2.

**Table 7.7**: Control Costs as Percentages of Baseline Costs[a]

| Model Plant | Baseline Costs[b] ($/Mg) | Regulatory Alternative I (%) | IIA (%) | IIB (%) | III (%) | IV (%) |
|---|---|---|---|---|---|---|
| **Standards** | | | | | | |
| 1 | 75.40 | 0 | 0 | 22.40 | 0 | 22.40 |
| 2 | 20.70 | 1.77 | 33.7 | 33.70 | 48.50 | 48.50 |
| 3 | 9.40 | 3.97 | 60.60 | 60.60 | 82.80 | 82.80 |
| 4 | 44.00 | 1.72 | 21.30 | 21.30 | 34.10 | 34.10 |
| 5 | 21.30 | 1.34 | 31.80 | 31.80 | 46.90 | 46.90 |
| 6 | 3.58 | 11.20 | 201.00 | 201.00 | 275.00 | 275.00 |
| 7 | 17.70 | 3.33 | 40.90 | 40.90 | 66.90 | 66.90 |
| 8 | 30.40 | 0 | 0 | 29.00 | 0 | 29.00 |
| 9 | 54.20 | 23.40 | 23.40 | 87.40 | 23.40 | 87.40 |
| 10 | 31.20 | 0 | 0 | 54.50 | 0 | 54.50 |
| 11 | 13.20 | 0 | 29.50 | 29.50 | 64.90 | 64.90 |
| 12 | 13.20 | 0 | 47.90 | 48.00 | 64.90 | 64.90 |
| **Guidelines** | | | | | | |
| 1 | 46.40 | 14.70 | 26.30 | 26.30 | 60.40 | 60.40 |
| 2 | 63.30 | 27.70 | 27.70 | 47.40 | 27.70 | 47.40 |
| 3 | 36.40 | 3.90 | 25.80 | 25.80 | 70.20 | 70.20 |
| 4 | -3.13 | [c] | [c] | [c] | [c] | [c] |
| 5 | 5.08 | 8.80 | 148.00 | 148.00 | 322.00 | 322.00 |
| 6 | 24.40 | 20.10 | 20.10 | 87.40 | 20.10 | 87.40 |
| 7 | -19.70 | [c] | [c] | [c] | [c] | [c] |
| 8 | -4.94 | [c] | [c] | [c] | [c] | [c] |
| 9 | 5.17 | 111.00 | 111.00 | 520.00 | 111.00 | 520.00 |
| 10 | 23.80 | 80.60 | 80.60 | 203.00 | 80.60 | 203.00 |
| 11 | 3.39 | 0 | 0 | 310.00 | 0 | 310.00 |
| 12 | 10.50 | 25.90 | 87.10 | 87.10 | 171.00 | 171.00 |
| 13 | 27.40 | 0 | 35.70 | 35.70 | 74.60 | 74.60 |
| 14 | 14.20 | 14.90 | 49.80 | 50.00 | 99.20 | 99.20 |
| 15 | 24.40 | 0 | 0 | 76.10 | 0 | 76.10 |
| 16 | 14.20 | 0 | 30.40 | 30.40 | 93.40 | 93.40 |
| 17 | 10.50 | 25.10 | 86.50 | 86.50 | 168.00 | 168.00 |

[a] Control costs used for calculating percentages are enterprise costs (1987 $) from Tables 7.5 and 7.6.

[b] Baseline costs are 1987 $/Mg from Table 7.4. For the Standards, the costs are capital and operating costs. For the Guidelines, they are operating costs only.

[c] Percentages are not meaningful because the baseline cost is negative.

# Chapter 8

# Characteristics of the Municipal Waste Combustion Industry

The demand for MWCs is derived from the demand for services that collect and dispose of the large volume and variety of wastes Americans produce. This chapter looks into the market structure for these services: who and what organizations *generate* MSW (and thereby "demand" its collection), who and what organizations supply *collection* services (and thereby "demand" disposal services), and who and what organizations supply ***disposal*** services, particularly those of MWCs. The term "MSW industry" includes the generation, collection, and disposal of MSW. The municipal waste combustion industry is a major component of the MSW industry. This chapter concludes with projections of the numbers of MWCs that will be affected by the Standards and Guidelines over the next five years.

## 8.1 Industry Profile

### 8.1.1 Generators

MSW generators demand—in the economic sense of the word—services that collect and dispose of MSW. These generators provide most of the demand for MWC services. This demand is called a derived demand because the generators generally do not directly purchase MWC services, but instead leave the purchase up to the collectors. There are four broad categories of MSW generators:

- Residential: Waste from single- and multiple-family homes.
- Commercial: Waste from retail stores, shopping centers, office buildings, restaurants, hotels, airports, wholesalers, auto garages, and other commercial establishments.
- Industrial: Waste such as corrugated boxes and other packaging, cafeteria waste, and paper towels from factories or other industrial buildings. Industrial MSW does not include waste from industrial processes, whether hazardous or nonhazardous.
- Other: Waste from public works such as street sweepings and tree and brush trimmings, and institutional waste from schools and colleges, hospitals, prisons, and similar public or quasi-public buildings. Infectious and hazardous waste from these generators are managed separately from MSW.

Households are the primary direct source of MSW, followed by the commercial sector. On average, each U.S. household directly generated 790 kg of solid waste in 1986. The commercial, industrial, and other sectors each directly generate smaller portions of MSW than households. The industrial sector manages most of its own solid residuals, whether MSW or industrial process wastes, by recycling, reuse, or self disposal. For this reason industry directly contributes only a small share of the MSW flow, although some industrial process wastes do end up as MSW.

Little empirical evidence is available about the factors that affect waste generation rates. However, without substantial changes in market conditions or policies that promote more recycling and the use of less residual-intensive production, packaging, and consumption methods, increases in economic activity and in the population indicate that MSW will increase in the future. Franklin Associates[12] estimates that MSW will increase at an annual rate of approximately 1.5 percent over the 1984-2000 period. This growth rate is slightly more than the population growth rate, indicating an increase in expected per-capita waste generation.

## 8.1.2 Collection and Disposal

Governments—local, state, and federal—play a large role in regulating and operating MSW management systems. Governmental influence, however, is limited. Material, engineering, geographic, cost, and other technical and economic conditions spell out some of the limits.

In addition, all MSW management systems ultimately involve private decision makers. Households and private firms generate most MSW, collect and transport MSW, build and operate MSW disposal systems, provide financing, and provide markets for recycled material. In some settings these private activities compete with public operations; in others, they provide factors of production and demand for outputs from public operations. Whatever the case, these technical and market relationships are important factors in conditioning the influence of local governments on MSW management generally and the economic impact of changes in the cost of MWC in particular.

### 8.1.2.1 Collection

Local governments, especially in more urbanized areas, often take the lead in organizing MSW management and, in many cases, providing collection and disposal services. A wide variety of reasons explain this involvement: concern for the public health threat of uncollected or improperly disposed MSW, natural economies of scale in organizing and performing MSW collection and disposal, and a concern for the negative externalities—litter, noise, smells, traffic—sometimes associated with private collection and disposal. These negative externalities are not necessarily unhealthy, but they are detractions from public welfare.

How extensive is the local government role? Four market structures for MSW collection predominate:

- Public monopoly—public agency collects all MSW.
- Private monopoly—private firm(s) collect(s) all MSW in a specific area under a franchise agreement and is (are) reimbursed by the local government.

- Competitive—public agency and private firm(s) both collect MSW.
- Self service—generators haul their MSW to disposal sites.

Most residential refuse is collected under the first three market structures; about 50 percent is collected under the first. A large fraction of private service is provided by contractors selected by local governments. In such cases, the government plays a role in selecting the private collection firm, specifying the terms and conditions of collection, and paying the private collector for the service.

#### 8.1.2.2 Disposal

Waste disposal facilities, especially landfills, are more likely to be owned or operated by local governments than are collection services.[1] In general, local governments feel a strong responsibility to ensure that MSW generated and collected in their jurisdiction has a proper place to go. Owning or operating the disposal facility provides them with the necessary control. Table 8.1 shows the ownership pattern for combustors. A sizable fraction of combustors and landfills are owned or operated by a regional service district. For example, the combustor in Duluth, MN, is owned and operated by a special service district created by the state legislature. This district has responsibility for wastewater and MSW treatment of some half dozen municipalities in the Duluth area. There is a trend—due to economies of scale in MSW management operations, and state government policy and legislation—toward forming sanitation authorities that encompass multiple local government jurisdictions.

In recent years, states have taken a more active role in shaping the MSW management practices in their jurisdiction. While the nature and level of state initiatives vary tremendously, many states have become active in providing a framework for organizing and planning local MSW management. States most prominent in this area are those confronting serious MSW management problems due to dense populations, large amounts of waste, limited space for disposal sites, and the vulnerability of their natural environment.

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[1] For waste disposal facilities it is common for the operator of the facility to be different from the owner.

**Table 8.1**: Ownership of Municipal Waste Combustors, by Size
(Number of MWC Plants, 1988)

| Ownership | ---- Waste Received ($10^3$ Mg per Year) ---- <br> <10 | 10-30 | 30-50 | 50-100 | 100-250 | >250 | ALL |
|---|---|---|---|---|---|---|---|
| Public | 7 | 12 | 8 | 8 | 14 | 10 | 59 |
| Private | 5 | 5 | 1 | 4 | 0 | 1 | 16 |
| Unknown[a] | | | | | | | 31 |
| TOTAL[b] | | | | | | | 106 |

[a] Ownership data currently are not available.

[b] Total represents number of respondents in a survey, not the total number of plants in the country.

The Federal Government, through legislation, regulation, demonstration, and guidance influences solid waste management in a variety of ways. Two laws that have been especially important to MWC activity have been the Public Utility Regulatory Policy Act of 1978 (PURPA) and the Tax Reform Act of 1986. Under PURPA regulations, independent small power generators have better opportunities, under more favorable financial terms, to provide electricity to electric utilities. This has spurred the development of MWCs that produce electricity. The Tax Reform Act of 1986, on the other hand, has reduced the tax and financing advantages available to private owners of new MWCs. Although many upcoming MWC projects are "grandfathered" under the Act, in the long run the Tax Reform Act will promote municipal ownership.

### 8.1.3 Decision Making

The design and operation of a MSW management system requires many decisions. These decisions are constrained by technical and economic factors and have implications for generators and managers of solid waste as well as for suppliers of inputs of MSW management services (labor, land owners, etc.) and area residents.

For example, governments decide which institutional arrangement to use for waste collection and disposal. Depending on the institutional arrangements, public and private decision makers must choose the amount and type of solid waste to generate (the demand side) and disposal processes to provide—recycling, combustion, and landfilling (the supply side). For each process they must determine the appropriate locations, scales, and design lifetimes. Imposition of the Standards and Guidelines will affect these choices.

### 8.1.3.1 Private Decision Making

Households and firms that generate waste respond to increases in the price of waste collection by reducing the amount of waste generated. The proportionate reduction may not be large, but if the price increase is large enough, the effect will be noticeable. By the same token, however, if cost increases in the MWC portion of the management system are not fully reflected in prices or are not tied to the amount of waste generated, there will be little or no change in waste generation attributable to the Standards and Guidelines beyond that associated with "income effects" due to changes in taxes.

Similarly, firms that collect, transport, and/or dispose of waste are assumed to respond to changes in the cost of production by adjusting their input mix to keep costs down and by passing as much of the remaining cost increase on to their customers (as price increases) as market conditions and contractual arrangements allow. In the case of a new MWC plant, the prospective owner has a broader set of available options for reducing cost, including changing the disposal technology selected or not building a plant at all. In the end, however, local market conditions must be seen by the prospective owner as supporting a disposal price that covers the minimum cost method of providing disposal services. The extent that MWC owners can raise prices and the degree to which this is accompanied by a change in the amount of waste combusted depends on the demand for combustion services in the local market. This demand depends on the share of combustion services used, the availability of substitutes, and the demand for disposal services generally. While institutional conditions associated with local, state, or federal policies will affect these determinants of demand, in this analysis private parties accept such institutional conditions as given and make production and investment decisions so as to maximize profit or, equivalently in a competitive market, minimize the cost.

#### 8.1.3.2 Government Decision Making

Government decision making is of particular concern in this analysis due to the large role that government plays at every level, especially the local level, in shaping MSW management systems. Theoretical and applied economic literature does not provide much positive guidance on the behavior of governments. On the other hand, normative literature on MSW management decision making, much of it aimed at decision making by public officials, often assumes that cost minimization, sometimes referred to as "project economics," is the implicit basis on which decisions regarding MSW management are reached. Consequently, this literature addresses methods and means by which the decision maker can make the correct, cost-minimizing choice. Authors who are not enthusiastic about conventional waste disposal options couch their arguments against extensive MSW combustion and for recycling in cost-minimizing terms. Thus, it seems that local or municipal MSW system decision making represents cost minimization, subject to the constraint that all MSW must be collected and properly disposed. It differs from private decision making in that the minimum cost is assessed based on centralized accounting of costs of various combinations of MSW management alternatives, some of which may not be feasible for a private firm due to institutional or financial constraints.

## 8.2 Baseline Projections

To analyze the impact of the Standards and Guidelines, estimated levels of new activity in relevant markets must be compared before and after regulation. The baseline is what the world would be like if there were no Standards and Guidelines. The baseline conditions are compared with conditions as they are projected to be under various regulatory alternatives.

The baseline level of MWC activity depends on how much solid waste is generated and what other waste disposal methods are available and in use, including landfilling and recycling. Thus, baseline projections should take into account not only solid waste combustion but also solid waste generation and the amount of solid waste managed by other major methods.

EPA compiled MSW data for 1986, the last year for which such data are reasonably complete. EPA adjusted the 1986 data for differences in definitions and coverage. This meant subtracting auto bodies, sewage sludge, some construction waste, some recycled items, and the like from the 1986 data, and making other adjustments to bring the data in line with the definition of MSW used for the Standards and Guidelines. It was not possible to identify and subtract out items littered and self disposed; such items are ignored in the projections. MWC ash that was not landfilled with MSW in 1986, that is, ash that was "monofilled" in landfills dedicated to ash, was subtracted, and the assumption made that all future increases in MWC ash will be monofilled and not treated as MSW.

Included in the collected data are several published projections of MSW generation and disposal. The most useful projections, and the ones that form the basis of the baseline projections for the Standards and Guidelines, were prepared by Franklin Associates for EPA.[12] The adjustments made to the 1986 data were applied to the Franklin Associates projections, and values for 1991 and 1996 were interpolated. MWCs affected by the Guidelines are those existing and those placed under construction by the end of 1989, all of which should be operating in 1991.[2] Similarly, MWCs affected by the Standards in the first five years will be those operating in 1996, less MWCs covered by the Guidelines. The adjusted projections for MSW to be landfilled holds reasonably constant, and therefore was set at a constant value. The remainder is projected to be recycled or combusted.[3] The projections are in Table 8.2.

(EPA's goal for the nation for 1992, set in the *Agenda for Action*, is to reduce MSW by 25 percent using source reduction and recycling techniques. In the *Agenda* EPA projects that 20 percent of MSW will be combusted and 55 percent will be landfilled in 1992.[14] The Standards and Guidelines

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[2] The substitution scenario for the Guidelines allows for the closure of some existing MWCs. This is explained in the next chapter.

[3] At the same time EPA was nailing down baseline projections for the Standards and Guidelines, it also was preparing baseline projections for the parallel landfill air emission CAA §111 standards and guidelines. Fixing the amount of MSW to be landfilled and assuming the remainder will be recycled or combusted is an analytical convenience that appears to be a pretty good guess of what actually will happen.

**Table 8.2**: MSW Disposal Projections

| Disposal Method | 1986 ($10^6$ Mg) | 1991 ($10^6$ Mg) | 1996 ($10^6$ Mg) |
|---|---|---|---|
| Landfilling | 188.1 | 188.1 | 188.1 |
| Recycling | 15.3 | 17.2 | 19.7 |
| Combusting | 14.4 | 29.4 | 44.3 |
| TOTAL | 217.8 | 234.7 | 252.1 |

require substantial materials separation. Table 8.2 shows 17.2 and 19.7 million Mg for recycling in 1991 and 1996, or 7.3 and 7.8 percent of the totals, respectively—not exactly the desired 25 percent. Similarly, only 12.5 and 17.6 percent of MSW is projected in this regulatory impact analysis to be combusted in 1991 and 1996, respectively. This situation may seem to be a paradox. However, the baseline projections for the Standards and Guidelines are only for analytical purposes, and should not be interpreted as alternatives to the goals and projections used in the *Agenda*. To the extent the nation recycles more than 7.3 and 7.8 percent of MSW in 1991 and 1996, there will be a reduced demand for MWC and landfill services, and the nationwide costs and emission reductions associated with the Standards and Guidelines will be smaller. On the other hand, to the extent the nation combusts more than 12.5 and 17.6 percent of the MSW in 1991 and 1996, the demand for MWC services will be larger, and the nationwide costs and emissions associated with the Standards and Guidelines will be larger.)

EPA inventoried all MWCs operating or under construction in 1988, and collected announcements of new MWCs planned for construction through 1994. The total capacity of these plants substantially exceeded what would be needed to combust 44.3 million Mg of MSW. (See Table 8.2.) The announced but not yet begun MWCs therefore were cut back, but the proportion of each type and size of announced plants was held constant. To arrive at the final baseline projection numbers of MWCs that will be affected by the Standards and Guidelines, EPA applied the two different capacity utilization assumptions described above in Section 7.1.4 and below in Table 8.3.

The baseline projections are summarized in Table 8.3 in the form of scaling factors. Each factor is the number of "real world" MWCs represented by the matching model plant. (It may appear odd to have fractional numbers of plants, but the factors that result from the baseline projection process does not produce whole numbers.) There will be about 65 MWCs affected by the Standards. (The Series A total for Table 8.3 is about 67 and the Series B total, which is smaller because each MWC is assumed to combust more MSW by operating more hours, is about 63.) There are about 113 existing MWCs that are projected to remain open, and another 67 that will begin construction in time to bring the total number of MWCs affected by the Guidelines to about 180. (The Series A total is about 184 and the Series B total, about 177.)

**Table 8.3**: Model Plant Scaling Factors

| Model Plant | Abbreviation | Scaling Factor<br>Series A[a] | <br>Series B[b] |
|---|---|---|---|
| | **Standards** | | |
| 1 | MB/WW (small) | 16.81 | 16.81 |
| 2 | MB/WW (mid-size) | 7.28 | 6.75 |
| 3 | MB/WW (large) | 8.49 | 7.88 |
| 4 | MB/REF | 3.24 | 3.00 |
| 5 | MB/RC | 3.24 | 3.00 |
| 6 | RDF | 5.29 | 4.88 |
| 7 | RDF/CF | 3.31 | 3.00 |
| 8 | MOD/EA | 3.35 | 3.00 |
| 9 | MOD/SA (small) | 1.80 | 1.80 |
| 10 | MOD/SA (mid-size) | 7.13 | 6.38 |
| 11 | FBC/CB | 2.06 | 1.88 |
| 12 | FBC/BB | 4.54 | 4.13 |
| | **Guidelines** | | |
| 1 | MB/REF/TG | 5.53 | 5.53 |
| 2 | MB/REF/RG | 22.75 | 22.75 |
| 3 | MB/REF/RK | 4.78 | 4.78 |
| 4 | MB/WW (large) | 11.05 | 10.13 |
| 5 | MB/WW (mid-size) | 17.51 | 15.39 |
| 6 | MB/WW (small) | 9.30 | 9.30 |
| 7 | RDF (large) | 5.00 | 5.00 |
| 8 | RDF (small) | 14.10 | 14.10 |
| 9 | MOD/SA/TR | 19.56 | 18.75 |
| 10 | MOD/SA/G | 46.60 | 46.50 |
| 11 | MOD/EA | 8.38 | 8.38 |
| 12 | MB/RWW | 2.43 | 2.43 |
| 13 | TRANS MOD/EA | 2.11 | 1.64 |
| 14 | TRANS MB/WW | 2.91 | 2.34 |
| 15 | TRANS RDF (large) | 4.22 | 3.31 |
| 16 | TRANS RDF (small) | 2.64 | 2.08 |
| 17 | TRANS MB/RWW | 4.27 | 3.44 |
| — | Unassigned | 1.087 | 1.090 |

[a] Series A is based on the annual operating hours given in Table 7.2.

[b] Series B is based on 8,000 annual operating hours, except that model plants with the special conditions noted in Table 7.2 have the annual operating hours given in that Table.

# Chapter 9

# Economic Analysis Objectives and Methodology

## 9.1 Introduction

Economic analyses serve a variety of functions. They can tell us something about the affordability of regulations, whether regulations will be inflationary, whether they will be efficient in achieving their purposes, whether they will alter production technology or the types of goods consumers purchase, and whether some groups will be adversely affected out of proportion to their contribution to pollution. Economic analyses give EPA insight in how to draft regulations so that positive impacts will be maximized and negative impacts minimized. The analyses produce much of the input data needed for benefit analyses. The degree any and all of these functions are met depends on many factors. Although the resources devoted to conducting an economic analysis generally are in proportion to how costly the regulation might be to the economy, the usefulness and accuracy of the economic findings relate as well to the availability of reliable data and the predictability of the sector(s) of the economy that will be regulated.

The reader is encouraged to read the economic analysis reports[4,5] for a complete description of the economic analysis objectives and methodology.[1]

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[1] The Research Triangle Institute (RTI) prepared two separate economic analyses for

This chapter begins with a look at some of the special features that have influenced both how the detailed analytical and procedural objectives were formulated, and what the analysis is able to show.

### 9.1.1 Special Features of the Analysis

The economic analysis conducted for development of the Standards and Guidelines has some special features that make it different from other analyses for CAA §111 actions. These features relate to the nature of the economic activity surrounding MWCs, to the types of pollutants and their control devices, and to an internal EPA desire to coordinate its regulatory activities. The features:

- A mix of public and private MWCs will be regulated. Most regulations apply to public enterprises or to private businesses, but not to both. The two types of owners experience different market conditions and react to regulation differently.
- MWCs operate as components of mostly-integrated MSW collection and disposal systems in local, partly-regulated markets. There are almost as many different market structures as there are local areas. The relative absence of a free competitive market, and the great diversity of local conditions, make it difficult to predict what prices are likely to change and who will be most affected. This means that no market mechanism will cause control costs to be passed through in a particular manner, such as by increases in MWC tipping fees, property taxes, or MSW collection charges. It has been difficult for EPA to speculate about average potential tipping fee increases, and all but impossible to say anything at all about the statistical distribution of potential absolute or percentage tipping fee increases.
- Each air pollution control measure targets a handful of pollutants, so that traditional cost/effectiveness measures are of questionable usefulness. This is because the only meaningful way to add up reductions

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EPA, one for the Standards and one for the Guidelines. A substantial effort was made to integrate the two studies, for example, by using consistent projections of MSW flows to combustors. However, EPA and RTI have not analyzed the interrelationship of the Standards and Guidelines. The economic and environmental impacts of the Guidelines depend to some degree on the stringency of the Standards, and vice versa. This interrelationship is particularly important in the substitution scenarios described in Section9.3.4.

of different pollutant emissions into a measure of effectiveness is to add up the *benefits* of the emission reductions, and most of these benefits can not be quantified, let alone monetized.

- Simultaneous with development of the Standards and Guidelines, EPA and some states are developing other regulations for various facets of MSW disposal operations. This creates real problems in defining the baseline conditions for the Standards and Guidelines, and it creates real problems in coordinating regulations. The baseline is supposed to reflect what the world would be like if there were no Standards and Guidelines. But it seems as though everything relating to MSW generation and disposal is changing all at once. The regulations EPA has promulgated and has in the pipeline are a big part of the reason for that change. Without a well defined and reasonably stable baseline it is hard to isolate and understand what changes may be spawned by the Standards and Guidelines. The fact that so many regulatory (and legislative) initiatives are in the mill makes it hard to be sure that all interactions have been considered and that unintended effects will be avoided.

- EPA is initiating a new, improved, but not yet widely understood procedure for discounting and annualizing regulatory costs. It is called two-stage discounting. In it, capital control costs are discounted and annualized differently from operating control costs. Fortunately for the Standards and Guidelines, the new procedure produces almost the same results as the old procedure, assuaging the concerns of some analysts not yet convinced that two-stage discounting is proper.

## 9.2 Objectives

EPA attempts to develop regulations that are protective of the environment and the public health and welfare, that are the the least disruptive to the economy, and that do no undue harm to small entities. To do this, EPA analyzes the potential economic and environmental impacts of regulatory alternatives, and uses the findings to help shape the form and content of the final regulatory package. For the Standards and Guidelines, this broad objective translates into specific analytical and procedural objectives:

- To analyze market response to regulation

  - How might prices in general, and MWC tipping fees in particular, change after the Standards and Guidelines take effect?
  - How might regulation affect preferences for one or another MWC technology, and affect the balance among landfilling, combusting, recycling, and other MSW disposal activities?
  - What will the national costs and environmental impacts be?
  - Who will pay, how, and how much?

- To aid in regulatory decision making
  - Are there economic—cost/effectiveness, benefit-cost, cost-distributional (equity), or economic efficiency—arguments for favoring one or another regulatory approach or regulatory alternative?
  - Should different sizes of MWCs be regulated differently? Should there be a cutoff size below which MWCs would not be regulated?

- To facilitate coordination
  - How should the Standards and Guidelines affect or be affected by parallel air regulations being developed for MSW landfills? How should the Standards and Guidelines relate to other ongoing EPA regulatory activities relating to MSW disposal?
  - How can the Standards and Guidelines best fit into and promote EPA's national MSW disposal goals advanced in *An Agenda for Action*[14]?
  - Does economic modeling reveal or highlight problems with engineering data? If so, how significant are the problems and what corrective action is warranted?
  - Is the regulatory baseline, including the baseline projections of MWCs (number, type, capacity, capacity utilization, etc.), reasonable and suitable?

The objectives of the benefits analysis are discussed in Chapter 12.

## 9.3 Methodology

### 9.3.1 Inputs

To accomplish these objectives, EPA first developed needed economic inputs:

- Inventory and baseline projections of MWCs
  - Ownership (public or private)
  - Emissions; use of APCDs
  - Baseline economics (costs and revenues) of combustion
- Model plants and regulatory alternatives
  - Control costs, emissions, and equipment lifetimes for each model plant for each regulatory alternative
  - Amount of MSW received, amount combusted, and ash generated by each model plant
  - Number of existing or projected plants each model plant represents
- Profile of MSW disposal activities
  - How municipalities make MSW disposal decisions
  - Characteristics of governments and firms that build, own, and/or operate MWCs
  - How MSW generators and MSW collectors currently respond to economic forces (tipping fees, local taxes, etc.)

### 9.3.2 Overall Approach

With model plant capital and operating costs for the baseline and each regulatory alternative, and model plant throughput, EPA computed the cost of combusting a Mg of MSW for each model plant for each regulatory alternative, under conditions of both public ownership and private ownership. The condition of public ownership was selected as most useful for the analysis, and thereafter was used in all calculations presented in this regulatory impact analysis. The cost-per-Mg figures then were used, both on the model plant level and aggregated to the national level, as surrogates for MWC tipping fee increases. The distributional impacts on local governments and households were calculated, as reported below in Chapter 11.

EPA studied municipal decision making in the area of MSW disposal, and constructed two models to predict how municipalities might react to the Standards and Guidelines. For the Standards, the model is an econometric equation that predicts the likelihood that any particular local government will landfill or combust MSW, and if the selection is combustion, the likelihood of selecting a particular type of MWC. Unfortunately, this model is not able to predict whether existing MWCs might be closed. Therefore, for the Guidelines, the decision model is a least-cost simulation model that predicts only whether an existing MWC will be closed in favor of a new but more economical MWC of like size. Both models operate on the cost-per-Mg figures developed as described in the preceding paragraph, and are used in the analysis of substitution.

In the next step, EPA switched from an enterprise accounting base to a social accounting base. In enterprise accounting, the real (constant dollar) municipal bond rate of 4 percent is used as the rate for annualizing capital costs of control. In social accounting, the capital costs of control are annualized at a rate reflecting society's real opportunity cost of capital, which is assumed to be 10 percent. (If the operating costs had not been expressed as annual costs, EPA would have annualized them using society's real opportunity cost of consumption, which is assumed to be 3 percent.)[2] The national social cost of the Standards and Guidelines were computed for the no-substitution and substitution scenarios. For the no-substitution scenario and the Guidelines substitution scenario, the scaling factors in Table 8.3 were used to aggregate model plant data up to the national scale. For the Standards substitution scenario, different scaling factors were used, as explained in Section 9.3.4 below. Emission reductions and other environmental impacts also were aggregated to the national scale with the scaling factors.

Finally, many inputs, such as the rates used for discounting and annualizing, were changed for a sensitivity analysis. Such analyses indicate how sensitive national regulatory costs are to changes in input values.

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[2] The computational difference between enterprise costs and social costs results in especially large differences in the present values of control costs. See references [4,5]. However, no present value statistics are used in this regulatory impact analysis.

### 9.3.3 Assumptions and Conventions

Myriad assumptions, analytical conventions, and underlying calculations form the basis for projecting the economic impacts of EPA regulations. Table 9.1 summarizes the principal assumptions, conventions, and calculated values used in this regulatory impact analysis. As just mentioned, EPA conducted numerous computer sensitivity analyses to see whether and how projected impacts would be different if some of these items are changed.

The first two entries in the table are self-explanatory. The third entry, the date for which impacts are evaluated, is January 1, 1995, five years after the assumed effective date of both the Standards and Guidelines. Except in unusual circumstances, EPA's horizon for projecting total annual costs of air regulations is five years. Because no closures of existing MWCs are projected after the initial adjustment to the Guidelines is made, the total annual costs for the Guidelines remain constant for essentially all years of the first equipment lifecycle of 15 years. For the Standards, the total annual costs will change year-by-year at least through the first equipment lifecycle, so the fifth year is only one "snapshot" of annual costs. Only MWCs projected to begin construction during the five years are analyzed. This is mathematically consistent with a projection that the annual amount of MSW combusted after 1996 (when MWCs begun in 1994 come on-line) will remain constant at 1996 levels in perpetuity.

The next five entries may be somewhat confusing to those unfamiliar with analytical protocols. EPA assumes that all capital costs of control for each model plant are incurred at the outset of an equipment lifecycle (equipment lifetime) of 15 years, that annual operating and maintenance expenditures and annual recovery credits are unchanging over the cycle, and that salvage value at the end of the cycle equals the cost of removing the worn-out equipment and restoring the site. To ensure that the length of the cycle does not unnecessarily cause cost and revenue profiles among cycles to be different, EPA has adjusted estimated plant life so that the duration of an equipment cycle is divisible into the economic lifetime of a plant a whole number of times. (If this were not done, it would be necessary

**Table 9.1**: Assumptions and Conventions Used in the Economic Analysis

**Effective date** for Standards and Guidelines: January 1, 1990

**Affected MWCs:** All MWCs placed under construction (A) on or after the effective date (Standards), or (B) before the effective date (Guidelines)

**Date for which impacts are evaluated:** January 1, 1995—5 years after compliance costs begin (MWCs begun after 1994 are not analyzed. The timing of construction of new MWCs over this 5-year analysis period is ignored.)

**Lifetimes of physical facilities**

- MWCs: Standards—30 years after compliance costs begin
  Guidelines—15 years after compliance costs begin
- APCDs: 15 years

**% utilization of daily capacity** (There are some exceptions. These percents remain constant over time.)

- Mass burn: 85%
- RDF and FBC: 83%
- Modular: 82%

**Monetary unit:** Constant (real) fourth quarter 1987 dollars

**Capital costs** for each MWC and APCD

- Incurred only at the outset of operation of the MWC or APCD
- Amortized over the lifetime of the MWC or APCD

**Annual operating costs and revenues** for each MWC and APCD

- Invariant over the lifetime of the MWC or APCD
- Proportional to MWC capacity utilization (for analysis purposes when alternative capacity utilization rates are introduced)

**Market interest (discount) rate** for computing potential tipping fee increases and analyzing the distribution of costs (Rate is for public MWCs. Allowance for an equivalent rate for private MWCs would not change economic findings.)

- 4% real municipal revenue bond rate

**Social interest (discount) rates** for computing social costs

- 10% for capital
- 3% for consumption

to use plant life, rather than the equipment cycle, as the analysis unit, because the last equipment cycle in the life of a plant would have more or fewer years to amortize capital costs. EPA believes this adjustment does not introduce bias into the calculations.) For MWCs, EPA assumes that the equipment cycle is exactly one-half of the economic lifetime of new plants and equal to the remaining economic lifetime of existing plants. None of these assumptions and procedures is needed to avoid computational complexity. However, the detail and accuracy of the engineering cost data are inadequate to support greater realism.

EPA further assumes that model plant capacity utilization, and its analytical counterparts employment and annual emission reductions, remain unchanged through an equipment cycle. This assumption avoids computational complexity as well as controversy relating to the evaluation of an uneven flow of emission reductions over time. The assumption that annual operating costs and revenues vary in proportion to capacity utilization is needed only for investigating the sensitivity of the economic findings to the assumed model plant capacity utilization percentages.

These assumptions lead to an analytical convenience, namely, annual air pollution control costs, for both model plants and for the nation as a whole, are *independent* of the number of equipment cycles analyzed. All findings reported in this regulatory impact analysis are based on the analysis of only one equipment cycle, but are equally valid for two, three, or any number of cycles.[3]

The economic analysis reports[4,5] give the derivation of the interest (or discount) rates shown as the last two items in Table 9.1. In addition to the rates shown, EPA developed the weighted average cost of capital for private MWCs, which is, in the terminology of Table 9.1, the real market interest (or discount) rate for private MWCs. Because this private rate is not used in calculating national social costs, and has only a small effect on the results of an analysis of the distribution of costs, it is not used in this regulatory impact analysis. EPA uses the new two-stage discounting procedure for computing national social costs; hence two social rates are shown in the table. (The term "social costs" refers to the regulatory costs to the nation as a whole. Largely due to the combined effects of taxes and interest (or discount) rates, national social costs are *not* the sum of costs felt by each affected MWC. Costs felt by each affected MWC are called "enterprise costs" in this regulatory impact analysis.)

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[3] Some *baseline* capital costs—not APCD costs—for new MWCs are amortized in this regulatory impact analysis over the expected 30-year lifetime of the MWC. Also, the economic reports[4,5] have some present value calculations of APCD costs where the number of equipment cycles analyzed does make a difference.

Additional assumptions are mentioned below as they relate to substitution.

## 9.3.4 Substitution Scenarios

### 9.3.4.1 Concept

The second of the analytical objectives listed above is to find answers to the question:

> How might regulation affect preferences for one or another MWC technology, and affect the balance among landfilling, combusting, recycling, and other MSW disposal activities?

If the regulatory costs might cause municipalities to do more landfilling and less combusting of MSW, the result might in the long run be neither cheaper for society nor environmentally safer. Furthermore, regulatory costs might cause municipalities to stop building, say, RDF MWCs and to build mass burn MWCs in their places. The consequences of such a switch also could be of concern. EPA therefore uses two scenarios in the economic analysis. In the first, municipalities do just as projected in the baseline. The Standards and Guidelines are assumed to not cause any change in the types of MWCs used. In the second, municipalities are allowed to change their minds. Two substitution decision models are used, one for the Standards and a different one for the Guidelines.

### 9.3.4.2 No-Substitution Scenario

In this scenario municipalities continue to operate existing MWCs, and build new ones, as described in the baseline projections (Chapter 8). The costs of the regulatory alternatives are as depicted in Tables 7.5 and 7.6.

The demand for combustion services is assumed to be perfectly inelastic, that is, constant in the face of rising costs. The inelasticity could be due to inelastic demand *per se*, or to institutional arrangements that do not allow any increase in costs to be passed on directly to waste generators. Thus, this no-substitution scenario is a reasonably worst-case scenario in that it leads to projections of higher national costs of control than are likely to occur. It also leads to projections of greater emission reductions than are likely.

#### 9.3.4.3 Substitution Scenario

**Standards.** The substitution scenario for analysis of the Standards employs an econometric model and many ratios to arrive at new scaling factors to replace those for Series A, Table 8.3. There are new scaling factors for each regulatory alternative. EPA reran most of the economic analysis models with the new scaling factors to obtain the results for the substitution scenario reported in the next chapter.

The econometric model is based on data on actual municipal choices to build landfills, mass burn MWCs, modular MWCs, and RDF MWCs. Engineering cost data, MWC financial and operating parameters, landfill costs, site information, educational attainment of residents, population density, and manufacturing intensity for many local areas have been processed into a set of equations that can be used to produce probabilities. For a municipality with a given set of these attributes and an MSW disposal decision to make, the model indicates the probability that landfilling will be selected, the probability that a mass burn MWC will be selected, and so on. EPA aggregates these probabilities across municipalities to estimate the shares of yearly MSW processing capacity for each of the four technologies. Changes in costs due to regulation result in new share estimates.

The next step for EPA is to decide how much MSW is available for disposal. The annual fill rate for landfills that are expected to close during the 5-year analysis period is added to the baseline combustion rate used in the no-substitution scenario. With this information, EPA applies a sequence of ratios to convert the estimated technology share numbers into revised scaling factors.

The substitution scenario findings are examined in Chapter 10. The reader should be aware of the uncertainties involved when interpreting these findings. First, the econometric model has shortcomings. It could not incorporate recent technology, such as FBC MWCs, or some upcoming regulatory costs, such as those that will result from the landfill air emission CAA §111 standards and guidelines. (EPA is able to account for RCRA Subtitle D regulatory costs.) Econometric models by their nature use observations from the past to develop relationships to be used in projections of the future. The MSW disposal industry is very dynamic; past relationships may be altered and therefore may not be the best predictors of future decisions. Second, there is no easily definable baseline for the substitution scenario. As each successive regulatory alternative is studied, the number and mix of MWCs changes. There is no good way to find the incremental costs and emission reductions associated with moving from one regulatory alternative to another without tabulating emissions and costs for MSW that is not combusted, and that is outside the scope of this analysis. In short, the substitution scenario findings are informative but not adequate by themselves for selecting a regulatory alternative.

**Guidelines.** When the operating costs of an existing MWC exceed the operating costs *plus* capital amortization for a new MWC on a per-Mg combusted basis, it usually is time to retire the old plant. EPA makes these comparisons for Guidelines model plants under baseline conditions and for each regulatory alternative. The findings, described in Chapter 10, are that the three refactory wall mass burn MWCs, which have no energy recovery, are likely to shut down and be replaced by mass burn and modular MWCs *even in the absence* of the Guidelines. After this adjustment, EPA finds no case where the Guidelines costs would induce the closure of an existing plant.

The costs for a new MWC comparable to an existing MWC are estimated using regression analysis applied to new plant cost data for (1) mass burn technology for consideration as a substitute for large existing plants, and (2) modular technology for consideration as a substitute for small existing MWCs. Baseline capital costs, operating costs, and energy recovery credits are regressed on plant capacity. A good fit between estimated and actual values is obtained.

The regression equations are used to estimate the per-Mg costs of new MWCs identical in size to each of the mass burn and modular model plants for the baseline and each regulatory alternative.[4] Wherever the per-Mg costs for the existing plant exceed 115 percent of the per-Mg costs for the comparable new plant, a substitution is assumed. The scaling factors in Table 8.3 are retained.

Just as a few cautionary notes are needed to interpret the substitution findings for the Standards, so too with the Guidelines. While the engineering cost estimates used in this analysis are suitable for comparing costs of slightly different sizes and features for one particular type of plant, they are not as suitable for comparing costs of different types of MWCs. Indeed, RDF and FBC MWCs are excluded from the substitution analysis for just this reason. EPA believes the RDF and FBC APCD costs are valid, but recognizes that the baseline plant cost data are not adequate for comparisons among combustor types. Furthermore, it is not clear that cost minimization is the sole criterion in local MSW disposal decisions. Existing institutional arrangements, such as legal agreements to deliver certain quantities of MSW to existing combustors, may preclude the closure of old plants even when they are money losers. (Recall that the Standards substitution econometric model is based on how local governments actually have behaved in a world where cost minimization is only one of many considerations.) Finally, the cost comparisons do not include landfills as alternatives to MWCs.

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[4] At this step in the analysis, EPA assumed that the level of control for the new replacement MWC would be the same as that for the existing MWC, both in the baseline and for each of the Guidelines' regulatory alternatives. This simplification overlooks the probability that there will be many situations where the new MWC would be required to have more stringent controls that would the existing MWC of similar size.

# Chapter 10

# Economic Analysis Findings

## 10.1 Scope

The economic analysis accomplished many, but not all, of the objectives listed above in Section 9.2. The principal findings are highlighted here; the reader is encouraged to read the separate economic analysis reports (references [4] and [5]) for details. Regulatory costs are presented in two forms: enterprise costs (experienced by the MWCs) and social costs (experienced by society as a whole). Enterprise costs yield insights about potential tipping fee increases at MWCs. Enterprise costs also yield insights about how the Standards and Guidelines might influence municipalities' choices of MSW disposal technology in the years ahead. The national social costs are the national costs traditionally associated with emission regulations. In a very general way they can be compared with the emission reductions resulting from regulation. Chapter 10 presents both the national social costs and the national emission reductions, and describes how sensitive these numbers are to the analysis inputs of (1) rates used for annualizing capital costs and (2) MWC capacity utilization percentages. Finally, Chapter 10 discusses some of the costs that are not included in the tabulations.

Economic analysis findings regarding the distribution of costs are in Chapter 11.

The tables in Chapter 10 present data according to scenario and regulatory alternative. The no-substitution scenario is the way the world would be if municipalities proceeded just as depicted in the baseline projections. That is, there is an assumption that the baseline projections are accurate and that the Standards and Guidelines will not influence the number and type of MWCs that will be built and/or used over the analysis period. The substitution scenario for the Standards is a projection of what the world would be like if municipalities allow the EPA regulation to influence their decisions on whether to landfill or combust MSW, and where decisions are to combust, on what types of MWCs to select. The substitution scenario for the Guidelines gives municipalities only the decision of whether to replace existing MWCs with new MWCs. More information on how the substitution scenarios are constructed is in Section 9.3.4.

**Control costs for materials separation, $NO_X$, and regulatory alternative IIB′, as well as associated emission reductions, are *not* included in the tabular results. Revised PM emission limits for existing MWCs *have not* been used in generating the tables.** Materials separation costs are expected to be negligible in the long run for the average MWC. Emission reductions attributable to materials separation have not been calculated. Total national annual social $NO_X$ control costs in the fifth year after the Standards are proposed will be about $30 million, or about $2 per Mg of MSW combusted. Capital costs will be about $97 million. National $NO_X$ emissions will drop by about 12,000 Mg/year, or by about 40 percent. For the Guidelines, regulatory alternative IIB′ national annual social costs will be about $20 million less than equivalent costs for regulatory alternative IIB, or about a decrease of $0.70 per Mg of MSW combusted. Capital costs will be about $60 million less than those for regulatory alternative IIB. National emissions of MWC organics, HCl, and PM will be about the same from regulatory alternative IIB levels.[1] National emissions of $SO_2$ will be about five percent higher than regulatory alternative IIB levels.

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[1] Costs and emission reductions described in this paragraph are based on the capacity utilization assumption used in Table 10.6.

## 10.2 Enterprise Costs

Table 10.1 shows, for the fifth year after the Standards and Guidelines are proposed, the national enterprise costs by scenario and regulatory alternative. Capital costs are annualized at an estimated 4 percent real municipal bond rate and added to annual operating costs to derive the annual costs. Calculations are performed for each model plant, and the results are scaled to the national level using the Series A scaling factors from Table 8.3. In most cases, national enterprise costs are not good measures of national costs of regulation, because taxes and market interest rates distort the calculations. Here, however, public ownership of MWCs is assumed, so that taxes never directly enter the calculations. As a result, the difference between these enterprise costs and the social costs in Table 10.5 is entirely due to selection of an interest rate for annualizing capital costs.

### 10.2.1 National Enterprise Costs and Tipping Fees

Enterprise costs indicate how municipalities may react to the Standards and Guidelines. If localities were to pass control costs along to MSW collectors through tipping fees, the result would be a substantial jump in those fees. See Table 10.2. The national average potential percentage increase in fees is 23 percent for the Standards (regulatory alternative IV), and about the same for the Guidelines (regulatory alternative IIB). For equivalent numbers on the model plant scale, see Table 7.7. MWC costs, including ash disposal costs, very roughly average only one-half of total MSW disposal costs. The other one-half is for collection and transportation of MSW. Thus, a 23 percent tipping fee increase probably would be no more than a 10 to 15 percent increase in overall MSW disposal costs. In any event, it is unlikely that all control costs would be passed along through tipping fee increases. Some of the costs may be picked up by local taxpayers, and some by private firms that own or operate MWCs.

**Table 10.1**: National Cost Impacts
(Enterprise Costs,[a] 1987 $, for Average Capacity Utilization[b])

| Scenario and Regulatory Alternative | Standards | | |
|---|---|---|---|
| | Capital Costs[c] ($$10^6$) | Annual Costs[d] ($$10^6$/yr) | Annual Costs per Mg MSW[e] ($/Mg) |
| No-Substitution Scenario | | | |
| RA I | 30.5 | 5.15 | 0.37 |
| RA IIA | 183 | 89.6 | 6.45 |
| RA IIB | 216 | 106 | 7.10 |
| RA III | 514 | 128 | 9.23 |
| RA IV | 548 | 145 | 9.69 |
| Substitution Scenario | | | |
| RA I | 29.7 | 5.02 | 0.37 |
| RA IIA | 121 | 62.5 | 6.35 |
| RA IIB | 149 | 75.8 | 7.11 |
| RA III | 321 | 80.5 | 9.09 |
| RA IV | 347 | 93.0 | 9.65 |

| Scenario and Regulatory Alternative | Guidelines | | |
|---|---|---|---|
| | Capital Costs[c] ($$10^6$) | Annual Costs[d] ($$10^6$/yr) | Annual Costs per Mg MSW[e] ($/Mg) |
| No-Substitution Scenario | | | |
| RA I | 517 | 82.2 | 2.82 |
| RA IIA | 978 | 229 | 7.84 |
| RA IIB | 1,190 | 294 | 10.00 |
| RA III | 2,370 | 484 | 16.60 |
| RA IV | 2,580 | 550 | 18.70 |
| Substitution Scenario | | | |
| RA I | 275 | 49.3 | 1.78 |
| RA IIA | 713 | 198 | 7.14 |
| RA IIB | 913 | 264 | 9.01 |
| RA III | 1,970 | 424 | 15.30 |
| RA IV | 2,170 | 490 | 16.70 |

[a] National enterprise costs are the sum of the regulatory costs incurred by each MWC, with capital costs annualized at the estimated 4 percent real municipal bond rate. Control costs for materials separation, $NO_X$, and regulatory alternative IIB$^{f}$ are not included in this table. See text page 10-2.

[b] Cost impacts are based on Series A scaling factors from Table 8.3. Most MWCs are assumed in Series A to operate about 7,300 hours per year.

[c] Capital costs are for one APCD lifetime of 15 years and are untouched by discounting procedures.

[d] Annual costs are annual operating costs plus capital costs annualized at 4 percent.

[e] Annual costs per Mg are costs from the preceding column divided by the annual amount of MSW combusted.

**Table 10.2**: Potential Percentage Increases in Tipping Fees Based on Full Pass Through of Enterprise Costs[a]

| Scenario and Regulatory Alternative | **Standards** Percentage Price Increase | **Guidelines** Percentage Price Increase |
|---|---|---|
| No-Substitution Scenario | | |
| RA I | 0.86 | 6.6 |
| RA IIA | 15 | 18 |
| RA IIB | 17 | 23 |
| RA III | 22 | 39 |
| RA IV | 23 | 44 |
| Substitution Scenario | | |
| RA I | 0.86 | 4.2 |
| RA IIA | 15 | 17 |
| RA IIB | 17 | 21 |
| RA III | 21 | 36 |
| RA IV | 23 | 39 |

[a] These percentages are computed by dividing the annual costs per Mg in Table 10.1 by the average 1988 tipping fee at resource recovery MWCs. Converted to fourth quarter 1987 dollars, that fee is $42.70. Control costs for materials separation, $NO_X$, and regulatory alternative IIB$'$ are not included in this table. See text page 10-2.

### 10.2.2 Municipalities' Choices of Technology

**Standards.** Model plant enterprise costs are used to analyze substitution effects. For the Standards, the effects of substitution are summarized in Table 10.3. As the regulatory alternatives become progressively more stringent, the share of MSW going to mass burn and RDF MWCs declines, the share going to modular MWCs remains about constant, and the share going to landfills increases. In this regulatory impact analysis, MSW diverted to landfills carries with it no emission control costs and no emission reductions. For this reason, and because municipalities tend to behave in a cost-minimizing manner, the enterprise costs for the substitution scenario in Table 10.1 are less than those for the no-substitution scenario. Control costs for $NO_X$ and materials separation have not been incorporated into this substitution analysis.

**Guidelines.** For the Guidelines, the substitution analysis consists of a cost-minimizing model that reviews the enterprise costs and "allows" municipalities to scrap existing MWCs and build replacements of comparable size if it will save money. The analysis reveals only three likely substitutions, and all three take place in the baseline. The refactory-walled mass burn MWCs are shutdown. Model plants 1 and 3 are replaced by new mass burn MWCs, and model plant 2 is replaced by a new modular MWC. All costs in Chapter 7 are before-substitution costs. Table 10.4 is an update of Table 7.7 for the three new MWCs, which retain the model plant number of the original MWCs. Comparison of Tables 10.4 and 7.7 reveals the cost savings behind the substitutions. These cost savings account for the differences between the two scenarios in Table 10.1. Control costs for materials separation and regulatory alternative IIB′ have not been incorporated into this substitution analysis.

**Table 10.3**: Substitution Effects of the Standards:
Percent of MSW[a] Allocated to Each of Four Disposal Technologies

| Disposal Technology | Baseline (%) | Regulatory Alternative I (%) | IIA (%) | IIB (%) | III (%) | IV (%) |
|---|---|---|---|---|---|---|
| **Mass Burn** | 12 | 12 | 9 | 9 | 8 | 8 |
| **Modular** | 1 | 1 | 1 | 1 | 1 | 1 |
| **RDF** | 5 | 5 | 3 | 3 | 2 | 2 |
| **Landfill** | 82 | 82 | 87 | 87 | 89 | 89 |
| TOTAL[a] | 100 | 100 | 100 | 100 | 100 | 100 |

[a] Percentages apply *only* to MSW allocated in this analysis to these four technologies; this MSW does *not* include waste for recycling, for existing MWCs, or for other technologies, such as FBC.

**Table 10.4**: Substituted Costs for the Guidelines Analysis:
Percent Change in Enterprise Control Costs over Baseline
*After* Substitution

| Model Plant[a] | Baseline Costs[b] ($/Mg) | Regulatory Alternative I (%) | IIA (%) | IIB (%) | III (%) | IV (%) |
|---|---|---|---|---|---|---|
| 1 | 25.20 | 1.39 | 38.1 | 38.1 | 53.7 | 53.7 |
| 2 | 56.90 | 0 | 0 | 23.0 | 0 | 23.0 |
| 3 | 28.90 | 1.44 | 24.5 | 24.5 | 36.5 | 36.5 |

[a] All other model plant costs remain as shown in Tables 7.3, 7.4, 7.6, and 7.7.

[b] Baseline costs are 1987 $ per Mg of MSW combusted, and in the substitution scenario replace the figures given in Table 7.7.

## 10.3 Social Costs

### 10.3.1 National Social Costs

Table 10.5 shows, for the fifth year after the Standards and Guidelines are proposed, the national enterprise costs by scenario and regulatory alternative. Capital costs are annualized at an assumed 10 percent social opportunity cost for capital and added to annual operating costs to derive the annual costs. Calculations are performed for each model plant, and the results are scaled to the national level using the Series A scaling factors from Table 8.3. The annual cost of the Standards in the fifth year of implementation will lie in the $107 to $168 million range (regulatory alternative IV), while the corresponding annual cost of the Guidelines will lie in the $302 to $343 million range (regulatory alternative IIB).

**Table 10.5**: National Cost Impacts
(Social Costs,[a] 1987 \$, for Average Capacity Utilization[b])

| Scenario and Regulatory Alternative | Standards | | |
|---|---|---|---|
| | Capital Costs[c] ($\$10^6$) | Annual Costs[d] ($\$10^6$/yr) | Annual Costs per Mg MSW[e] (\$/Mg) |
| **No-Substitution Scenario** | | | |
| RA I | 30.5 | 6.41 | 0.46 |
| RA IIA | 183 | 97.2 | 6.99 |
| RA IIB | 216 | 115 | 7.70 |
| RA III | 514 | 150 | 10.80 |
| RA IV | 548 | 168 | 11.20 |
| **Substitution Scenario** | | | |
| RA I | 29.7 | 6.26 | 0.46 |
| RA IIA | 121 | 67.6 | 6.86 |
| RA IIB | 149 | 82.0 | 7.69 |
| RA III | 321 | 93.8 | 10.60 |
| RA IV | 347 | 107 | 11.10 |

| Scenario and Regulatory Alternative | Guidelines | | |
|---|---|---|---|
| | Capital Costs[c] ($\$10^6$) | Annual Costs[d] ($\$10^6$/yr) | Annual Costs per Mg MSW[e] (\$/Mg) |
| **No-Substitution Scenario** | | | |
| RA I | 517 | 104 | 3.55 |
| RA IIA | 978 | 269 | 9.23 |
| RA IIB | 1,190 | 343 | 11.70 |
| RA III | 2,370 | 583 | 20.00 |
| RA IV | 2,580 | 657 | 22.40 |
| **Substitution Scenario** | | | |
| RA I | 275 | 60.7 | 2.19 |
| RA IIA | 713 | 228 | 8.20 |
| RA IIB | 913 | 302 | 10.30 |
| RA III | 1,970 | 506 | 18.20 |
| RA IV | 2,170 | 580 | 19.80 |

[a] National social costs are the sum of the regulatory costs incurred by each MWC, with capital costs annualized at the assumed 10 percent social opportunity cost for capital. Control costs for materials separation, $NO_X$, and regulatory alternative IIB$'$ are not included in this table. See text page 10-2.

[b] Cost impacts are based on Series A scaling factors from Table 8.3. Most MWCs are assumed in Series A to operate about 7,300 hours per year.

[c] Capital costs are for one APCD lifetime of 15 years and are untouched by discounting procedures.

[d] Annual costs are annual operating costs plus capital costs annualized at 10 percent.

[e] Annual costs per Mg are costs from the preceding column divided by the annual amount of MSW combusted.

### 10.3.2 Sensitivity of Costs

**Interest (Discount) Rate.** The annual costs of the Standards and Guidelines decline as the rate used for annualizing the capital cost component declines. Compare Tables 10.1 and 10.5. Table 10.1 is based on a 4 percent rate, while Table 10.5 is based on a 10 percent rate. The drop in annual costs between the social and enterprise accounts is in the 8 to 20 percent range, depending on the relative size of the capital component of the annual cost for each regulatory alternative. This comparatively small change in annual costs for a proportionately much larger change in the rate used for annualization indicates that national costs are reasonably insensitive to small variations in rates.[2]

**MWC Capacity Utilization.** Table 10.5 is based on the average (Series A) MWC capacity utilization factors described in Sections 7.1.4 and 8.2. Table 10.6 presents the national social costs for the no-substitution scenario for the Series B high capacity utilization factors. This increase in capacity utilization means fewer MWCs are needed to combust the same quantity of MSW, and hence, fewer APCDs are needed. A comparison of Tables 10.5 and 10.6 shows that national social cost impacts decline as capacity utilization increases. The changes are modest; this means that projected cost impacts are relatively insensitive to small, but reasonable, changes in capacity utilization.

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[2] Present values of control costs for the Standards and Guidelines are more sensitive to discounting procedures and rates than annual costs are sensitive to annualization procedures and rates. Present values are not necessary to a basic understanding of cost impacts, and therefore are omitted from this regulatory impact analysis.

**Table 10.6**: National Cost Impacts
(Social Costs,[a] 1987 \$, for High Capacity Utilization[b])

| Scenario and Regulatory Alternative | Standards | | |
|---|---|---|---|
| | Capital Costs (\$$10^6$) | Annual Costs (\$$10^6$/yr) | Annual Costs per Mg MSW (\$/Mg) |
| No-Substitution Scenario | | | |
| RA I | 28.1 | 6.10 | 0.44 |
| RA IIA | 168 | 96.3 | 6.93 |
| RA IIB | 200 | 114 | 7.63 |
| RA III | 472 | 145 | 10.40 |
| RA IV | 504 | 163 | 10.90 |

| Scenario and Regulatory Alternative | Guidelines | | |
|---|---|---|---|
| | Capital Costs (\$$10^6$) | Annual Costs (\$$10^6$/yr) | Annual Costs per Mg MSW (\$/Mg) |
| No-Substitution Scenario | | | |
| RA I | 509 | 103 | 3.54 |
| RA IIA | 936 | 264 | 9.05 |
| RA IIB | 1,140 | 339 | 11.60 |
| RA III | 2,240 | 566 | 19.40 |
| RA IV | 2,440 | 641 | 21.80 |

[a] Social costs are computed as in Table 10.5. Control costs for materials separation, $NO_X$, and regulatory alternative IIB′ are not included in this table. See text page 10-2.

[b] Cost impacts are based on Series B scaling factors from Table 8.3. Most MWCs are assumed in Series B to operate 8,000 hours per year.

## 10.4 Emission Reductions

### 10.4.1 National Emission Reductions

Table 10.7 shows, for the fifth year after the Standards and Guidelines are proposed, projected national emission reductions by regulatory alternative and scenario.[3] The PM, $SO_2$, and CDD/CDF columns are used in Chapter 12 for calculating benefits. Baseline emissions are shown. Emission reductions for the substitution scenario for the Standards are hard to interpret because the number of affected MWCs declines as the regulatory alternatives become more stringent. In some places increased stringency brings *smaller* national emission reductions with *larger* national costs. (Even where *increased* stringency results in *smaller* emission *reductions*, increased stringency should not result in increased *emissions*. The smaller emission reductions would be due to a decline in the number of MWCs. MSW would be diverted to recycling markets and landfills, which have emission characteristics altogether different from MWCs. If this regulatory impact analysis were able to include disposal costs and emissions associated with the MSW diverted to recycling markets and landfills, this odd result might not occur.)

### 10.4.2 Sensitivity of Emission Reductions

**Interest (Discount) Rate.** For the no-substitution scenario, emission reductions projected by economic modeling are insensitive to changes in the rates used for discounting and annualizing. To the extent the rates affect enterprise costs it may indirectly influence substitution among technologies and, therefore, emission reductions. Such affects are likely to be minor.

**MWC Capacity Utilization.** MWC capacity utilization has minimal effects on emission reductions. See Table 10.8, which shows emission reductions for the no-substitution scenario under the high capacity utilization Series B assumption. Data for the substitution scenario have not been analyzed for sensitivity to capacity utilization. The capacity utilization assumption has a much larger effect on costs than on emission reductions, and therefore would be of concern if EPA were relying on cost/effectiveness arguments to support the Standards and Guidelines. Emission reductions for the Standards are unaffected by capacity utilization. For the Guidelines, higher capacity utilization yields slightly greater emission reductions. For both the Standards and Guidelines there is no difference in the flow of MSW between the average and high capacity utilization assumptions.[4]

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[3] For $NO_X$ emission reductions see page 10-2.

## 10.5 Untabulated Costs

Costs for $NO_X$ control and Guidelines regulatory alternative $IIB'$ became available too late to be incorporated into this regulatory impact analysis. Materials separation requirements were added to the Standards and Guidelines after most control costs had been developed, and for that reason materials separation costs have not been developed fully. Materials separation may be self-supporting for some MWCs, but not for others. Preliminary analysis indicates that, as recycling markets develop, the average MWC will experience little or no cost, and may even turn a profit on materials separation operations. If further analysis reveals potentially significant costs for some types or sizes of MWCs, incorporation of those costs into the regulatory impact analysis might require some restructuring of the computer models, baseline projections, and substitution scenarios. In addition to the $NO_X$, $IIB'$, and materials separation costs, there are other categories of costs for which impacts have not been analyzed here. These categories are explained below.

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[4] The small change in emission reductions for the Guidelines is attributable to the way capacity utilization data are used to generate the Series A and B scaling factors. For both series (in the no-substitution scenario) the number of MWCs in existence by mid-1988 is fixed, and the MSW flow is fixed. All adjustment for capacity utilization is made for MWCs to be constructed in late 1988 and in 1989, and these MWCs generally are different from the older MWCs. This difference causes the small difference in emission reductions for the Guidelines between Tables 10.7 and 10.8.

**Table 10.7**: National Baseline Emissions and Regulatory Emissions Reductions — Average Capacity Utilization[a]
(Mg per Year)

| Scenario and Regulatory Alternative | Standards | | | | | |
|---|---|---|---|---|---|---|
| | CDD/CDF | CO | PM | $SO_2$ | HCl | Pb |
| **No-Substitution Scenario** | | | | | | |
| **Baseline** | 0.0152 | 5,470 | 7,540 | 42,000 | 49,300 | 127 |
| **RA I** | 0 | 0 | 5,220 | 0 | 0 | 88.5 |
| **RA IIA** | 0.0107 | 0 | 5,220 | 18,300 | 36,700 | 108 |
| **RA IIB** | 0.0115 | 0 | 5,960 | 19,300 | 39,500 | 124 |
| **RA III** | 0.0139 | 0 | 5,220 | 35,400 | 44,400 | 108 |
| **RA IV** | 0.0146 | 0 | 5,960 | 36,400 | 47,200 | 124 |
| **Substitution Scenario** | | | | | | |
| **Baseline**[b] | — | — | — | — | — | — |
| **RA I** | 0 | 0 | 5,120 | 0 | 0 | 86.3 |
| **RA IIA** | 0.00781 | 0 | 3,440 | 13,700 | 25,700 | 77.9 |
| **RA IIB** | 0.00841 | 0 | 4,040 | 14,500 | 27,900 | 90.3 |
| **RA III** | 0.00916 | 0 | 2,980 | 22,400 | 27,700 | 68.6 |
| **RA IV** | 0.00974 | 0 | 3,550 | 23,100 | 29,900 | 81.6 |

| Scenario and Regulatory Alternative | Guidelines | | | | | |
|---|---|---|---|---|---|---|
| | CDD/CDF | CO | PM[c] | $SO_2$ | HCl | Pb |
| **No-Substitution Scenario** | | | | | | |
| **Baseline** | 0.193 | 25,600 | 11,300 | 86,200 | 108,000 | 247 |
| **RA I** | 0.140 | 10,700 | 6,520 | 0 | 0 | 154 |
| **RA IIA** | 0.175 | 10,700 | 6,520 | 30,700 | 75,500 | 192 |
| **RA IIB** | 0.180 | 10,700 | 8,230 | 34,500 | 86,300 | 240 |
| **RA III** | 0.186 | 10,700 | 6,520 | 69,100 | 91,600 | 192 |
| **RA IV** | 0.191 | 10,700 | 8,230 | 72,900 | 102,000 | 240 |
| **Substitution Scenario** | | | | | | |
| **Baseline** | 0.120 | 16,400 | 7,400 | 84,600 | 105,000 | 169 |
| **RA I** | 0.0719 | 3,560 | 2,480 | 0 | 0 | 82 |
| **RA IIA** | 0.105 | 3,560 | 2,480 | 30,400 | 74,400 | 120 |
| **RA IIB** | 0.108 | 3,560 | 4,350 | 33,900 | 84,100 | 163 |
| **RA III** | 0.115 | 3,560 | 2,480 | 68,400 | 90,300 | 120 |
| **RA IV** | 0.118 | 3,560 | 4,350 | 71,900 | 99,900 | 163 |

[a] Emissions and emissions reductions are reported *only for affected MWCs*. MSW diverted to landfills in the Standards substitution scenario is not considered. Data are based on Series A scaling factors from Table 8.3. Most MWCs are assumed to operate about 7,300 hours per year.

[b] There is no baseline *per se* for this substitution scenario. Each successive regulatory alternative affects progressively fewer MWCs. Incremental analysis with this scenario is inadvisable.

[c] Revised PM emission limits for existing MWCs have not been incorporated in this table.

**Table 10.8**: National Baseline Emissions and Regulatory Emissions Reductions — High Capacity Utilization[a]
(Mg per Year)

| Scenario and Regulatory Alternative | Standards | | | | | |
|---|---|---|---|---|---|---|
| | CDD/CDF | CO | PM | $SO_2$ | HCl | Pb |
| No-Substitution Scenario | | | | | | |
| Baseline | 0.0152 | 5,470 | 7,540 | 42,000 | 49,300 | 127 |
| RA I | 0 | 0 | 5,220 | 0 | 0 | 88.5 |
| RA IIA | 0.0107 | 0 | 5,220 | 18,300 | 36,700 | 108 |
| RA IIB | 0.0115 | 0 | 5,960 | 19,300 | 39,500 | 124 |
| RA III | 0.0139 | 0 | 5,220 | 35,400 | 44,400 | 108 |
| RA IV | 0.0146 | 0 | 5,960 | 36,400 | 47,200 | 124 |

| Scenario and Regulatory Alternative | Guidelines | | | | | |
|---|---|---|---|---|---|---|
| | CDD/CDF | CO | PM[b] | $SO_2$ | HCl | Pb |
| No-Substitution Scenario | | | | | | |
| Baseline | 0.203 | 26,400 | 11,400 | 86,600 | 108,000 | 248 |
| RA I | 0.149 | 11,200 | 6,520 | 0 | 0 | 155 |
| RA IIA | 0.185 | 11,200 | 6,520 | 30,800 | 75,300 | 192 |
| RA IIB | 0.190 | 11,200 | 8,290 | 34,700 | 86,500 | 241 |
| RA III | 0.196 | 11,200 | 6,520 | 69,200 | 91,300 | 192 |
| RA IV | 0.201 | 11,200 | 8,290 | 73,100 | 102,000 | 241 |

[a] Emissions and emissions reductions are based on Series B scaling factors from Table 8.3. Most MWCs are assumed in Series B to operate 8,000 hours per year.

[b] Revised PM emission limits for existing MWCs have not been incorporated in this table.

**Operator training.** Operator training and certification is essential to ensure proper operation of MWCs in accordance with good combustion practice. Operation of MWCs and the associated APCDs is complex, requiring qualified operators and supervisors. The Standards and Guidelines require certification of the shift supervisor and chief plant operator and development of a site-specific training manual for use in training all plant operators. The annual cost of operator training is expected to be minor.

**Governmental administration and enforcement.** Federal, state, and local governments incur costs to issue permits, monitor performance, and enforce compliance with current environment regulations for new and existing MWCs. The additional costs associated with the Standards and Guidelines have not been quantified; however, these costs are considered to be insignificant.

**Adjustment costs for displaced resources.** Three types of costs may occur while the economy adjusts to new regulations: underutilization of resources from lost output, resource reallocation costs (such as moving to a new location), and the operation of programs to help the unemployed. These costs are considered to be insignificant.

**Dead-weight welfare losses.** These costs are defined as the net losses in consumers' and producers' surplus that occur when the output of goods and services decreases in response to a regulatory action.[5] Because the costs of readily available substitutes, such as landfilling, are also increasing in response to environmental regulation and decreasing availability, insufficient change is expected in the baseline utilization of MWCs to warrant investigation of dead-weight welfare losses. The utilization of MWCs may change significantly, however, in response to increased social consciousness of the value of recycling and source reduction.

**Paperwork.** The resource cost for reporting and recordkeeping as required by the Standards (see Section 3.3 for requirements) is expected to be 65 person-years per year for the first three years following promulgation. The supporting statement for Standard Form 83, an OMB requirement under the Paperwork Reduction Act, discusses these costs in further detail. No paperwork burden costs have been estimated for the Guidelines.

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[5] Just as dead weight welfare losses from reduced combustion of MSW are not tabulated in this analysis, the emission reduction benefits that would accompany the reduction in combustion are not tabulated.

# Chapter 11

# The Distribution of Impacts (Regulatory Flexibility)

## 11.1 Who Pays How Much?

It is not clear how the Standards and Guidelines might change the way Americans pay for MSW disposal, and therefore which firms, municipalities, waste generators, taxpayers, users, or other groups will end up paying, and in what proportion. EPA has looked into impacts on households and local governments in detail, using impact measures developed in two other studies.[6,10] The results indicate that regulation is not likely to have *severe* adverse economic effects on any group. The household and governmental impact analyses are reported in Section 11.2. The Regulatory Flexibility Act (RFA) requires a broader look into whether there will be *significant* adverse economic effects and, if so, how those impacts will be distributed among small entities. The RFA and its associated regulatory flexibility analysis are the subject of Section 11.3.

## 11.2 Households and Governments

Analyzing the economic impacts of the Standards and Guidelines on households and governments is difficult because households and governments come in all sorts of sizes and income brackets and are, or will be, served by MWCs with widely varying compliance costs and financial structures. For each existing and planned MWC on file, EPA identified

- Ownership,
- Mg of MSW combusted annually,
- Type, and which model plant best represents the MWC, and
- Geographic location.

This information was merged with data from the 1980 Census of Population and Housing. Household income data from the census were recast in 1987 dollars with the GNP implicit price deflator. Because of difficulties in matching MWCs with service areas, the default procedures used had an underestimation bias for service area size to keep impact estimates conservative. Specifically, where the input data indicated an obvious mismatch—MWC capacity utilization less than about 50 percent or greater than 400 percent—the MWCs were excluded from this household and government impact analysis. (The fact that most areas have grown in population since the 1980 census has relatively little effect on this analysis because the resulting increase in generation of MSW should be offset by an enhanced financial base to pay for the controls.) Costs of the various regulatory alternatives were assigned to MWC plants based on the model plant designations. Because model plant costs are based on the assumption that the plants are just meeting federal standards (exclusive of the 1987 Guidance) for emissions in the baseline, there is an additional inherent upward, or conservative, bias in these impact estimates.

### 11.2.1 Household Impacts

Most MWCs, whatever their ownership, will try to pass increased costs on to their customers. Among these customers are households, which generate much of the MSW. Two indices are used by EPA's Office of Solid Waste in its Subtitle D Landfill Regulatory Impact Analysis.[6] They are a rough measure of the household burden associated with the regulation of things such as MWCs and landfills. The first index is an absolute measure of the cost of regulation per household, while the second is a relative measure of the cost of regulation per household. In the landfill analysis, a service area is defined as having severe household impacts if either

- Compliance cost per household exceeds $220, or
- Compliance cost per household exceeds 1 percent of median household income.

Based on either criterion, no MWC service area will experience severe household impacts under any of the regulatory alternatives. However, because of census data limitations this household impact analysis does not include service areas with a population less than 2,500. Additionally, results are based on the national average amount of waste generated per household, and on an assumption that all served households share equally in paying for compliance. In practice, the impact of the regulation on individual households would depend on actual waste generated, actual household income, and the method by which individual jurisdictions pass on costs to their customers. While these average impacts of compliance are not severe, there well may be special contractual or technical conditions, especially for small communities and service areas, where these MWC compliance costs, in combination with the costs of other environmental regulations, may impose unusual hardships.

For the Standards, under regulatory alternative IV, no service area will average control costs greater than $89 per household per year, or 0.5 percent of median household income. Costs for 90 percent of all households will average less than $30 per household per year, and less than 0.13 percent of median household income. The average annual household control cost is $20, translating to 0.08 percent of median household income.

For the Guidelines, under regulatory alternative IV, no service area will average control costs greater than $93 per household per year, or 0.5 percent of median household income. Costs for 90 percent of all households will average less than $58 per household per year, and less than 0.29 percent of median household income. The average annual household control cost is $27, translating to 0.12 percent of median household income. Impacts under regulatory alternative IIB′ would, of course, be significantly less.

For both the Standards and Guidelines, smaller service areas have slightly higher household impacts.

Under rare circumstances these results could be additive. That is, if a service area will have an old MWC subject to the Guidelines and a new MWC subject to the Standards, the adverse impacts could be greater than those reported for the Guidelines. EPA did not analyze this possibility. However, even where a service area is affected by both the Standards and Guidelines, the household impacts should be less than severe.

### 11.2.2 Local Government Impacts

Criteria different from those used for households were used to judge whether there might be severe impacts on local governments. *If*

- The sum of (1) the average sewerage and sanitation cost per household and (2) the average MWC control cost per household, exceeds 1 percent of median household income, *and if*
- The sum of (1) total current debt service and (2) additional debt service associated with capital costs for MWC control, exceeds 15 percent of total general revenue,

*then* the impacts are considered severe for the local government. This criterion matches one used in EPA's *Municipal Sector Study.*[10] It is a measure of a local government's ability to issue revenue bonds or obtain loans to raise the capital needed to comply with the Standards and Guidelines. A second criterion is derived from the Subtitle D landfill study.[6] *If*

- MWC control costs exceed 1 percent of total general expenditures,

*then* the impacts are considered severe for the local government. This criterion is a measure of a local government's ability to meet the yearly cost burden associated with the Standards and Guidelines.

To apply these two criteria, the MWCs owned by municipalities or counties, or jointly owned by municipalities and counties, were identified. For each of these public MWCs, the data collected for the household impact analysis were added to data from the 1982 Census of Governments. Government financial figures were inflated from 1982 to 1987 dollars using the

State and Local Government Expenditure Deflator. The criteria were applied only to publicly owned MWCs for which ownership and service area were specified in the data base as being the same. Assigning only one governmental unit to a facility may tend to overestimate government impacts for those MWCs that serve several jurisdictions by underestimating the financial base of the communities served. If assigning a single government to an MWC does not give severe impacts, the full assignment of all relevant governmental units with their greater combined resources to the plant is unlikely to give severe impacts. As in the case of the household analysis, application of the criteria was further limited to those service areas whose estimated waste generation roughly matched the capacity of the associated plants.

No local government will have severe impacts under the *Municipal Sector Study* criterion. However, under the Subtitle D criterion, the initial analysis indicated that many local governments will be severely affected. Each severe-impact case was investigated and in every case EPA found that the MWC served, or will serve, more than one jurisdiction, and that the financial base in the analysis is substantially smaller than the actual financial base for the MWC. With this supplementary information, EPA concludes that no local government will be severely impacted by the Standards and Guidelines.

Unfortunately, due to data limitations, local governments with fewer than 10,000 inhabitants could not be analyzed. For areas with larger populations, the analysis shows a very weak relationship between size and the severity of impacts using the second criterion. Specifically, smaller governments may have to devote a slightly larger proportion of their general expenditures to the control of MWC emissions than will larger governments.

## 11.3 Regulatory Flexibility Analysis

The RFA (Public Law 96-354, September 19, 1980) requires Federal agencies to give special consideration to the impact of regulations on small businesses, small organizations, and small governmental units. Small organizations are not affected by the Standards and Guidelines, and are not examined further here. The major purpose of the Act is to keep paperwork and regulatory requirements from getting out of proportion to the scale of the entities being regulated, without compromising the objectives of, in this case, the CAA. Another purpose is to involve the small entities in the regulatory development process. The paperwork burden on small entities has not been analyzed separately from that for all affected entities.

### 11.3.1 Small Entity Impacts

The RFA specifies that a regulatory flexibility analysis must be prepared if a proposed regulation will have (1) a significant economic impact on (2) a substantial number of small entities. Section 11.2 above addresses the severity of impacts on households and governments. For the RFA, however, the question is whether impacts are significant—not severe. One criterion that EPA has used specifies that economic impacts are significant whenever compliance costs will increase production costs by more than five percent. Chapter 10 indicates that on average the combustion costs per Mg MSW, as well as tipping fees, may increase by more than five percent for most regulatory alternatives for both the Standards and Guidelines. EPA has other criteria of significance. These relate to the availability of capital for small entities, possible closures among small entities, and whether compliance costs as a percent of sales for small entities are at least 10 percent higher than the same costs for large entities. These other criteria are not addressed here; EPA presumes from the first criterion that economic impacts are significant.

Will these significant economic impacts be felt by a substantial number of small entities? For regulations like the Standards and Guidelines, EPA often has applied a 20 percent rule: if more than 20 percent of small entities are significantly impacted, the specific concerns of the RFA must be addressed. Unfortunately, it is rarely clear what the 20 percent should be of. In this case it could be 20 percent of the small entities with MWCs—but almost by definition 100 percent of those entities will be significantly impacted—or 20 percent of small entities in the "industry," whatever that means. Regardless of how the criterion is viewed, EPA finds only one small business and only a handful of small governments with MWCs.

As described below, EPA has taken appropriate steps to involve small entities in the regulatory development process, and to mitigate potential adverse effects for small entities. This section of Chapter 11, together with the relevant portions of references [4] and [5], constitute the regulatory flexibility analysis required by the RFA.

Small entities that own or operate MWCs most likely will have small modular MWCs. For that reason the mitigation measures discussed at the end of this section focus on small MWCs as surrogates for small entities.

#### 11.3.1.1 Small Businesses

**Size Standards.** Small businesses are identified by the Small Business Administration general size standard definitions. These vary by Standard Industrial Classification (SIC) code. For SIC code 4953, Refuse Systems, small business concerns are those receiving less than $6 million per year averaged over the most recent three fiscal years.

**Inventory and Projections.** Using the 1988-89 *Resource Recovery Yearbook* and data gathered under CAA §114, EPA has compiled a list of firms with MWCs.[1] This list includes owners of MWCs currently in operation as well as owners of MWCs now in planning stages and MWCs under construction. Telephone contacts were made with those firms for which data were insufficient, to obtain annual sales figures and to confirm information about the firm's line of business and organizational structure.

Approximately one third of the firms have been identified as publicly held corporations; the remaining majority are privately held firms including corporations and limited partnerships. Some are very large and diversified firms, for example General Motors Corporation. Only one firm appears to have less than $6 million in annual sales, suggesting that small businesses will not be significantly impacted by the Standards and Guidelines. This is less than the "substantial number" criterion to trigger a regulatory flexibility analysis; therefore, a regulatory flexibility analysis for small businesses is not required.[2]

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[1] See references [4] and [5].

[2] The Standards and Guidelines may be applied to thousands of small commercial and institutional waste disposal incinerators, such as those at some shopping centers and office complexes. If this happens, it is resonable to assume that a substantial number of small businesses would be affected, and therefore, the provisions of the RFA would apply.

**Regulatory Impacts.** Impacts of the regulation on private firms may be direct or indirect in nature. Owners who must purchase and install control equipment, train employees, or change operating practices will be directly impacted. On the other hand, firms that supply services or equipment but do not own an MWC will be indirectly impacted, and may actually benefit from the regulation as demand for air pollution control technology and equipment increases. The extent of impacts for a specific MWC owner or supplier is dependent on the level of pollution control in place at the time of the regulation, local market conditions and contractual arrangements, the size of the MWC, and financial status of the firm.

Many of the privately-owned MWCs are large and were built (or are about to be built) under much more favorable tax and financing conditions than would likely apply to control equipment used to meet the Standards and Guidelines. The control costs for private owners will be higher than for public owners of MWCs. For private MWCs that have long term waste disposal contracts that include escalator provisions to cover contingencies such as pollution control equipment, these higher costs can be passed on to waste collectors and generators. Private MWCs generally have such arrangements.

In contrast, privately owned MWCs that do not have such long-term contracts will be adversely affected by the Standards and Guidelines. How adverse the effect will be depends on the cost of production of the private MWC relative to other local means of solid waste disposal. If, after the Standards and Guidelines, the private MWC still has relatively low costs of production, the Standards and Guidelines will reduce expected profits but will not force sale or closure of the MWC. If, however, control costs are large enough to increase costs of production beyond prevailing tipping fees at landfills or public MWCs, the private MWCs may have to close or may have to operate at a loss in the hope that tipping fees increase in the future.

Data from EPA's study suggests a great disparity in annual revenues between the smallest and the largest of firms. The relationship between impacts, MWC size, and firm size was examined. Impacts are greater for small model plants than for large model plants. Because of this indication of a relationship between the size of the plant and the severity of the impact, EPA has provided greater regulatory flexibility for small plants. Specific measures to address the needs of small MWCs include: size cutoffs built into the regulatory structure, less stringent requirements for small plants, and permission for states to make case by case judgements under the Standards and Guidelines.

Adverse impacts on related industries that may be affected by the Standards and Guidelines—such as APCD suppliers, trash collectors, recyclers, engineering consultants, and supporting technologies—are not expected; these firms will likely benefit from increased demand for their services.

### 11.3.1.2 Small Governments

**Size Standards.** The Regulatory Flexibility Act has defined the term "small governmental jurisdiction" to mean governments of cities, counties, towns, townships, villages, school districts, or special districts, with a population of less than 50,000.

**Application of the RFA Criterion.** The number of governmental jurisdictions having MWCs for which household impacts were estimated is 72. Of these, 12 are in communities with populations less than 50,000. This represents approximately 17 percent of the publicly owned facilities. The percentage probably applies to the entire population of MWCs. As is the case with small businesses, this is less than the "substantial number" criterion that would trigger a Regulatory Flexibility Analysis.

**Involvement and Financing** For a discussion of how local governments make financial decisions, see Chapter 8. Mitigation measures that can be taken by small governments to offset costs are discussed below.

### 11.3.1.3 Small Entity Involvement

EPA has encouraged the involvement of all concerned parties in the development of the Standards and Guidelines. On July 7, 1987 EPA published in the *Federal Register*[8] a notice of intent to develop the Standards and Guidelines. Early in 1988 EPA sent questionnaires to owners and operators of existing MWCs. The purpose was to obtain information not just on the engineering configurations of the plants, but to obtain detailed funding and other financial information to give EPA insight into the financial implications of alternative control measures. In the spring of both 1988 and 1989 EPA presented status reports on the Standards and Guidelines at the annual public meetings of the National Air Pollution Control Techniques Advisory Committee. The function of the Committee is to serve as a forum for involving industry and the public in the regulatory development process for air pollution emission controls. Owners of all existing MWCs, all firms involved in owning or operating MWCs, and a wide selection of public interest groups were invited to attend and participate in the Committee's meetings. In the autumn of 1988 EPA mailed a package of about a dozen documents covering most aspects of development of the Standards and Guidelines. The mailing went to substantially the same parties—over 300 in total. Recipients were invited to comment on all aspects of the development of the Standards and Guidelines.

When the Standards and Guidelines are proposed in the *Federal Register*, EPA will set a date and place for a public hearing on the proposals. Public comments on the proposals will be invited, and interested persons may present their comments in writing or in person at the public hearing.

#### 11.3.1.4 Mitigation Measures

There are several ways potentially significant adverse economic impacts on small entities will be mitigated. First, the Standards and Guidelines themselves contain mitigation measures. Several of the requirements are more lenient for smaller MWCs, particularly in the case of the Guidelines. To the extent the proportion of small-entity owners and operators of small MWCs exceeds the proportion of small-entity owners and operators of large MWCs, this leniency translates into an easing of the economic burden on small entities relative to large entities. Implementation of the Standards and Guidelines will include an appeals process for unusual or hardship situations. If the Standards or Guidelines will force an MWC to close, or will preclude construction of a new MWC, or will assign to a small entity control costs that are disproportionate to the pollution, then the entity will have the opportunity to appeal to the state for relief from the full burden of compliance.

Second, there are several things small governments can do in the face of steep compliance costs. In almost all cases these governments have available to them alternative waste disposal technology—landfilling—and many ways to expand source reduction, materials separation, and recycling programs. Small governments have the opportunity to join in, or join in forming, intergovernmental service districts, or to contract with neighboring waste disposal operations for disposal services. Whenever intergovernmental agreements lead to the construction of MWCs of larger capacity than otherwise would have been constructed, air pollution control costs per Mg MSW will shrink. In some instances small governments can exercise monopoly market power to restrict competition among landfills and MWCs to improve the financial viability of particular MWCs. Finally, small governments that want to combust MSW have the option of building and operating MWCs as public ventures, or arranging for the MWCs to be built and operated as private ventures. The small governments can investigate both financial markets and then select whichever approach offers the best terms.

Third, the Standards and Guidelines, as have standards and guidelines in the past, will stimulate advancement of both combustion and control technologies. Improved technology will, over the long run, make it cheaper for small entities to build and operate small MWCs. (Improved technology, of course, also will help owners of large MWCs, and thereby may not prove to be *more* helpful to small entities that it will be to large entities.)

Finally, the Public Utility Regulatory Policy Act of 1978 assures independent small electricity generators reasonably favorable terms when they sell power to electric utilities.

# Chapter 12

# Benefits

## 12.1 Introduction

This chapter presents benefit estimates for each of the regulatory alternatives with and without substitution. The estimated economic benefits associated with reduced pollutant emissions from MWCs reflect individuals' willingness to pay for cleaner air.

This analysis is not intended to serve as a comprehensive and rigorous quantification of all of the benefits associated with the Standards and Guidelines. The absence of sufficient exposure-response and/or valuation information prohibits a comprehensive benefits assessment from being undertaken at this time. Further, time and resource constraints restricted the level of rigor in this analysis. Finally, as with other analyses performed for this RIA, controversy exists regarding some of the specific techniques employed in this chapter. Nevertheless, substantial benefits were quantified based on the best physical effects and valuation information currently available, and on peer-reviewed evaluation procedures.

## 12.2 PM Benefits

This section summarizes the analysis undertaken to develop a valuation factor (benefit per Mg estimate) and presents benefit estimates for PM emission reductions. For a detailed description of the procedures employed, see *Revised Benefit Analysis of Hypothetical Particulate Matter Control Regulations for Selected Municipal Waste Combustors.*[3]

The PM benefit analysis employed the following three step procedure:

- Development of an exposure estimate for a given emissions change at selected MWCs,
- Estimation of health and welfare changes, and
- Valuation of the health and welfare changes and calculation of an estimate of the average PM benefit per Mg reduced.

Each of these steps is discussed in turn.

Previous PM benefit analyses have employed the linear rollback approach to calculate the magnitude of air quality improvements that would result from air pollution controls. This approach assumes concentration changes are strictly proportional to emission reductions. To avoid this simplifying assumption, the Model City Program (MCP) was employed in this assessment. The MCP is a database management system that imitates the performance of full-scale industrial source complex (ISC) modeling, and does so with a substantial savings of time and cost. The MCP models the dispersion of air pollutants throughout a defined region based on ISC simulation, thus allowing the conversion of emission rates into incremental ambient concentration data. These ambient concentration data are then combined with population data to obtain exposure estimates.

Forty-four sites existing in 1986 were selected for analysis. The selection of sites was based primarily on the availability of data. The 44 MWCs studied represented over half of the total emissions from all MWCs in 1986.

The next step in the benefit analysis was to estimate the health and welfare effects resulting from the estimated exposure. Quantitative concentration-response functions were obtained for the following effects categories:

- Mortality (from Schwartz and Marcus (1986))[1]
- Acute Morbidity (from Ostro (1987))[2]
- Household soiling and materials damage (from Mathtech (1983, 1986))[3]

Table 12.1 presents effects estimates from PM reductions for each regulatory alternative and scenario examined.

The final step in the benefit analysis was the valuation of effects. For mortality risk, a range of $1.6 to $8.5 million (1986 dollars) per statistical life saved[4] was employed to calculate mortality reduction benefits. This range was taken from Fisher, Chestnut, and Violette.[2] A best point estimate of $4.4 million was employed. This estimate was derived by averaging estimates from the 13 studies used by Fisher *et al.* to develop the $1.6 to $8.5 million range.

A cost of illness approach was employed to value morbidity effects. Components valued were

- Work loss days (valued at the wage rate),
- Reduced activity days (valued at half the wage rate), and
- Direct medical expenditures.

Household soiling and materials effects were valued using a supply and demand model for goods purchased to maintain a desired level of cleanliness. Benefit estimates were derived by comparing expenditures for laundry and cleaning products, and gas and electricity, before and after PM reductions were imposed.

Since actual control strategies were not yet defined at the time of this analysis, a hypothetical complete shutdown scenario was examined. Estimated PM benefits from this scenario ranged from a low estimate of $5,503 to a best point estimate of $15,912, to a high estimate of $38,241 per Mg.

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[1] See reference [3].

[2] See reference [3].

[3] See reference [3].

[4] For example, one statistical life would be saved if a one-in-a-million chance of dying were eliminated for a million people.

**Table 12.1**: National Annual Reductions in Adverse Effects from PM Emissions

| Scenarios and Regulatory Alternative | Standards<br>Mortality | Work Loss Days ($10^3$ days) | Restricted Activity Days ($10^3$ days) | Medical Expenditures ($10^6$ 1987 $) |
|---|---|---|---|---|
| No-Substitution Scenario | | | | |
| RA I | 11.1 | 41 | 226 | 1.5 |
| RA IIA | 11.1 | 41 | 226 | 1.5 |
| RA IIB | 12.7 | 47 | 258 | 1.8 |
| RA III | 11.1 | 41 | 226 | 1.5 |
| RA IV | 12.7 | 47 | 258 | 1.8 |
| Substitution Scenario | | | | |
| RA I | 10.9 | 41 | 222 | 1.5 |
| RA IIA | 7.3 | 27 | 149 | 1.0 |
| RA IIB | 8.6 | 32 | 175 | 1.2 |
| RA III | 6.3 | 24 | 129 | 0.9 |
| RA IV | 7.6 | 28 | 154 | 1.1 |

| Scenarios and Regulatory Alternative | Guidelines<br>Mortality | Work Loss Days ($10^3$ days) | Restricted Activity Days ($10^3$ days) | Medical Expenditures ($10^6$ 1987 $) |
|---|---|---|---|---|
| No-Substitution Scenario | | | | |
| RA I | 13.9 | 52 | 283 | 1.9 |
| RA IIA | 13.9 | 52 | 283 | 1.9 |
| RA IIB | 17.5 | 65 | 357 | 2.4 |
| RA IIB′ | 17.6 | 66 | 360 | 2.4 |
| RA III | 13.9 | 52 | 283 | 1.9 |
| RA IV | 17.5 | 65 | 357 | 2.4 |
| Substitution Scenario | | | | |
| RA I | 5.3 | 20 | 108 | 0.7 |
| RA IIA | 5.3 | 20 | 108 | 0.7 |
| RA IIB | 9.3 | 34 | 189 | 1.3 |
| RA III | 5.3 | 20 | 108 | 0.7 |
| RA IV | 9.3 | 34 | 189 | 1.3 |

To facilitate comparison with costs, all estimates were inflated to fourth quarter 1987 dollars using the GNP implicit price deflator for personal consumption expenditures. These benefit per Mg estimates were then multiplied by estimated PM emission reductions to estimate national benefits. Table 12.2 presents national PM benefit estimates for each regulatory alternative and scenario examined.

## 12.3 $SO_2$ Benefits

The $SO_2$ benefit estimates presented in this section were derived from earlier EPA-directed studies. In particular, benefit results presented in Chapter 6 of the Industrial Boiler $SO_2$ RIA[9] were employed. The Industrial Boiler $SO_2$ Benefit Analysis developed $SO_2$ benefit per ton valuation factors that, after adjustment, were multiplied by the MWC $SO_2$ emission reduction estimates to obtain MWC $SO_2$ benefits.

There are direct and indirect benefits associated with $SO_2$ emission reductions. Benefit estimates presented in the Industrial Boilers $SO_2$ RIA reflect direct $SO_2$ effects (morbidity, soiling and materials damage [residential facilities], and agricultural yield [soybeans, wheat, and oats]), as well as indirect $SO_4$ and other PM effects (visibility, morbidity, and soiling and materials damage). $SO_2$ benefit per ton estimates reported in this analysis ranged from $510 to $710 ($1983) depending on the control scenario selected.

Several adjustments were made to the $SO_2$ valuation factors presented in the Industrial Boilers $SO_2$ RIA. First, they were adjusted downward to remove the PM chronic morbidity benefit component. PM concentrations around the MWCs studied in the MWC PM benefit analysis were not above the estimated threshold level for which chronic morbidity effects begin to occur. Second, the valuation factors were adjusted upward by including mortality benefits from reduced PM. The estimated ratio of PM mortality to total PM benefits from the MWC PM benefit analysis was used to make this adjustment. Third, all benefit per ton estimates were converted to benefit per Mg estimates. Last, the valuations were inflated to 1987 dollars. The final valuation factors calculated ranged from $876 per Mg to $1,201 per Mg. The mid-point of this range, $1,038 per Mg, was used as a best estimate. Table 12.3 presents national $SO_2$ benefit estimates for each regulatory alternative and scenario examined.

**Table 12.2**: National Annual PM Emission Reductions and Associated Benefits

| Scenarios and Regulatory Alternatives | Standards | | | |
|---|---|---|---|---|
| | Emission Reductions (Mg) | Benefits | | |
| | | Low | Best | High |
| | | (10$^6$ 1987 $) | | |
| No-Substitution Scenario | | | | |
| RA I | 5,220 | 28 | 83 | 200 |
| RA IIA | 5,220 | 28 | 83 | 200 |
| RA IIB | 5,960 | 33 | 95 | 228 |
| RA III | 5,220 | 28 | 83 | 200 |
| RA IV | 5,960 | 33 | 95 | 228 |
| Substitution Scenario | | | | |
| RA I | 5,120 | 28 | 81 | 196 |
| RA IIA | 3,440 | 19 | 55 | 132 |
| RA IIB | 4.040 | 22 | 64 | 154 |
| RA III | 2,980 | 16 | 47 | 114 |
| RA IV | 3,550 | 20 | 56 | 136 |

| Scenarios and Regulatory Alternatives | Guidelines | | | |
|---|---|---|---|---|
| | Emission Reductions (Mg) | Benefits | | |
| | | Low | Best | High |
| | | (10$^6$ 1987 $) | | |
| No-Substitution Scenario | | | | |
| RA I | 6,520 | 36 | 104 | 249 |
| RA IIA | 6,520 | 36 | 104 | 249 |
| RA IIB | 8,230 | 45 | 131 | 315 |
| RA IIB$'$ | 8,300 | 45 | 132 | 318 |
| RA III | 6,520 | 36 | 104 | 249 |
| RA IV | 8,230 | 45 | 131 | 315 |
| Substitution Scenario | | | | |
| RA I | 2,480 | 14 | 39 | 95 |
| RA IIA | 2,480 | 14 | 39 | 95 |
| RA IIB | 4,350 | 24 | 69 | 166 |
| RA III | 2,480 | 14 | 39 | 95 |
| RA IV | 4,350 | 24 | 69 | 166 |

**Table 12.3**: National Annual $SO_2$ Emission Reductions and Associated Benefits

| Scenarios and Regulatory Alternatives | Standards: Emission Reductions (Mg) | Benefits: Low (10^6 1987 $) | Benefits: Best (10^6 1987 $) | Benefits: High (10^6 1987 $) |
|---|---|---|---|---|
| No-Substitution Scenario | | | | |
| RA I | 0 | 0 | 0 | 0 |
| RA IIA | 18,300 | 16 | 19 | 22 |
| RA IIB | 19,300 | 17 | 20 | 23 |
| RA III | 35,400 | 31 | 37 | 43 |
| RA IV | 36,400 | 32 | 38 | 44 |
| Substitution Scenario | | | | |
| RA I | 0 | 0 | 0 | 0 |
| RA IIA | 13,700 | 12 | 14 | 16 |
| RA IIB | 14,500 | 13 | 15 | 17 |
| RA III | 22,400 | 20 | 23 | 27 |
| RA IV | 23,100 | 20 | 24 | 28 |

| Scenarios and Regulatory Alternatives | Guidelines: Emission Reductions (Mg) | Benefits: Low (10^6 1987 $) | Benefits: Best (10^6 1987 $) | Benefits: High (10^6 1987 $) |
|---|---|---|---|---|
| No-Substitution Scenario | | | | |
| RA I | 0 | 0 | 0 | 0 |
| RA IIA | 30,700 | 27 | 32 | 37 |
| RA IIB | 34,500 | 30 | 36 | 41 |
| RA IIB′ | 37,000 | 32 | 39 | 44 |
| RA III | 69,100 | 61 | 72 | 83 |
| RA IV | 72,900 | 64 | 76 | 88 |
| Substitution Scenario | | | | |
| RA I | 0 | 0 | 0 | 0 |
| RA IIA | 30,400 | 27 | 32 | 37 |
| RA IIB | 33,900 | 30 | 35 | 40 |
| RA III | 68,400 | 60 | 71 | 82 |
| RA IV | 71,900 | 63 | 75 | 86 |

## 12.4 Unquantified Benefits

The national benefit analysis presented in this chapter for the Standards and Guidelines is incomplete in coverage. The analysis is incomplete in three ways:[5]

- Coverage of pollutants is limited,
- Coverage of effects categories from pollutants covered is limited, and
- The valuation of effects covered is sometimes incomplete.

Two potentially important pollutants for which emission reduction estimates have been obtained, but for which valuation factors do not exist, are CO and HCl. Adverse health effects that can result from low level CO exposure include aggravation of angina and other cardiovascular diseases, effects on the central nervous system, and reduced exercise capacity. A potentially major adverse effect from HCl exposure is materials degradation. In addition, two epidemiological studies have linked HCl exposure to dental erosion and high level exposures have been linked to adverse respiratory effects. HCl is also a minor contributor to acid rain.

Organics emission reductions were not valued in this analysis. This is not expected to be a major omission since cancer risks from MWC organics is expected to be small. Metal emission reductions were also not directly valued in this analysis. However, some of the benefits, such as mortality risk, most likely have been quantified within the PM benefit assessment. To the extent that categories of adverse effects from metal emissions were not covered within the PM benefit analysis, additional unquantified benefits may exist.

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[5] There is a fourth way this analysis might be considered to be incomplete. The analysis focuses on benefits associated with emission reductions, and does not itemize or evaluate benefits accruing simply from having uniform regulations in place. Many of these latter benefits are itemized in Section 4.3.1 above. They include technological innovation in combustion technology and pollution control, improvements in (and strengthening of) state permitting procedures for siting new MWCs, mitigation of NIMBY political pressure on public officials, and less frustration for private waste disposal firms that operate in several states and must comply with each state's requirements

Coverage of the effects from the pollutants studied in this report is also incomplete. Table 12.4 summarizes the potential effect categories and the effect categories valued in this analysis for each MWC pollutant.

Finally, even for effects valued, coverage is sometimes incomplete. For example, the PM and $SO_2$ morbidity valuations do not account for residual pain and suffering, the $SO_2$ agricultural effects valuation only covers three crops, and all of the mortality and morbidity valuations do not fully account for hardship on other family members. Given the limited coverage of this analysis, the national benefit estimates reported in this chapter may be best interpreted as low-end estimates and may not be directly comparable to national cost estimates.

## 12.5 Summary

Table 12.5 presents partial national MWC benefit estimates from PM, and $SO_2$estimated emission reductions for each regulatory alternative and scenario under study. The ranges presented should be interpreted with caution since they were calculated from the benefit ranges on each individual pollutant and these ranges are based on different uncertainty factors. For example, the $SO_2$ benefit range only reflects uncertainty over the control scenario selected in the Industrial Boilers $SO_2$ RIA, whereas the PM benefit range reflects uncertainty over the dose-response and valuation information employed.

**Table 12.4**: Types of Benefits Included in, and Excluded from, the Benefits Analysis

| Benefit Category | $SO_2$ | $SO_4$ | PM | CO | HCl | Organics |
|---|---|---|---|---|---|---|
| **Health Effects** | | | | | | |
| Mortality due to chronic exposure | – | – | X | – | – | – |
| Mortality due to acute exposure | – | – | X | – | – | – |
| Morbidity due to chronic exposure | X | – | – | – | – | – |
| Morbidity die to acute exposure | X | – | – | – | – | – |
| **Soiling and Materials Damage** | | | | | | |
| Residences | X | – | X | NA | – | NA |
| Commercial and Industrial Sites | – | – | – | NA | – | NA |
| **Visibility Climate Effects** | | | | | | |
| Local visibility | NA | X | – | NA | NA | NA |
| Non-local visibility | NA | X | – | NA | NA | NA |
| Visibility at national parks | NA | – | – | NA | NA | NA |
| Climate | NA | NA | – | NA | NA | NA |
| **Non-Human Biological Effects** | | | | | | |
| Agriculture | X | – | NA | NA | – | NA |
| Forestry | – | – | NA | NA | – | NA |
| Fisheries | – | – | NA | NA | – | NA |
| Ecosystem | – | – | NA | NA | – | NA |

X = Included in this benefit analysis
– = Excluded from this benefit analysis
NA = Not applicable

**Table 12.5**: Partial National Annual Benefits
From Reducing MWC Emissions

| Scenarios and Regulatory Alternatives | - **Standards** - - - - Benefits - - - | | |
|---|---|---|---|
| | Low | Best | High |
| | - ($10^6$ 1987 $) - | | |
| No-Substitution Scenario | | | |
| RA I | 23 | 83 | 200 |
| RA IIA | 44 | 102 | 223 |
| RA IIB | 50 | 115 | 251 |
| RA III | 59 | 120 | 243 |
| RA IV | 65 | 133 | 272 |
| Substitution Scenario | | | |
| RA I | 28 | 81 | 196 |
| RA IIA | 31 | 69 | 148 |
| RA IIB | 35 | 79 | 172 |
| RA III | 36 | 70 | 141 |
| RA IV | 40 | 80 | 164 |

| Scenarios and Regulatory Alternatives | - **Guidelines** - - - - Benefits - - - | | |
|---|---|---|---|
| | Low | Best | High |
| | - ($10^6$ 1987 $) - | | |
| No-Substitution Scenario | | | |
| RA I | 36 | 104 | 249 |
| RA IIA | 63 | 136 | 286 |
| RA IIB | 75 | 167 | 356 |
| RA IIB′ | 77 | 171 | 362 |
| RA III | 97 | 176 | 332 |
| RA IV | 109 | 207 | 403 |
| Substitution Scenario | | | |
| RA I | 14 | 39 | 95 |
| RA IIA | 41 | 71 | 132 |
| RA IIB | 54 | 104 | 206 |
| RA III | 74 | 109 | 178 |
| RA IV | 87 | 144 | 252 |

# Chapter 13

# Weighing Some of the Benefits and Most of the Costs

## 13.1 Evaluation Criterion

Benefit-cost analysis provides a framework for assessing the potential changes in society's well-being under each of the regulatory alternatives of the Standards and Guidelines. Using the Hicks-Kaldor compensation principle, society is judged to be better off if potential net benefits (benefits minus costs) are positive and potential gainers are able to compensate potential losers.

## 13.2 Qualifications

Because of data paucities, the application of the benefit-cost methodology to evaluation of the regulatory alternatives results in a comparison of some of the potential benefits with almost all of the potential costs. Consequently, a regulatory alternative that has quantified potential benefits less than the quantified potential costs *does not necessarily imply* society's well-being is worsened. Furthermore, the regulatory alternative that yields the greatest level of quantified potential net benefits *does not under these conditions imply* the greatest improvement.

The estimated costs and benefits for the substitution scenario are not compared in this section because of severe lack of coverage. Calculated benefits for this scenario reflect only emission reductions from remaining MWC sites and do not credit emission reductions for sites that "switch" to landfilling. Furthermore, landfilling costs and emissions are not included in the estimates.

## 13.3 Results

The estimates of some of the potential benefits and most of the potential costs for the Standards and Guidelines are displayed in Table 13.1. Despite incomplete coverage of the benefits, regulatory alternative I results in predicted positive net benefits for both the Standards and Guidelines. This indicates an unambiguous improvement in society's well-being for this alternative. Unfortunately, the benefit analysis is particularly incomplete for the more stringent regulatory alternatives, since potentially large benefits from acid gas control are not quantified. Without complete coverage of the benefits, EPA cannot conclude anything about the net benefits of the other alternatives. Hence, it is not possible to identify the alternatives that result in the greatest improvement in society's well-being.

**Table 13.1**: National Social Costs and Partial National Benefits From Reducing MWC Emissions $(10^6\ 1987\ \$)$[a]

| Scenario and Regulatory Alternative | - - - **Standards** - - - | | - - - **Guidelines** - - - | |
|---|---|---|---|---|
| | Annual Costs | Partial Annual Benefits | Annual Costs | Partial Annual Benefits |
| No-Substitution Scenario — Costs and Benefits *over Baseline*[b] | | | | |
| RA I | 6.41 | 83 | 104 | 104 |
| RA IIA | 97.2 | 102 | 269 | 136 |
| RA IIB | 115 | 115 | 343 | 167 |
| RA III | 150 | 120 | 583 | 176 |
| RA IV | 168 | 133 | 657 | 207 |
| No-Substitution Scenario — *Incremental* Costs and Benefits[d] | | | | |
| RA I | 6.41 | 83 | 104 | 104 |
| RA IIA | 90.8 | 19 | 165 | 32 |
| RA IIB | 17.8 | 13 | 74 | 31 |
| RA III | 35.0 | 5 | 263 | 9 |
| RA IV | 18.0 | 13 | 74 | 31 |

[a] Costs are from Table 10.5. Benefits are the best estimates (mid-range values) from Table 12.6. This table does *not* incorporate (1) costs for $NO_X$ control, (2) costs for materials separation, (3) costs for best acid gas controls on existing MWCs with capacity of 2,000 Mg per day or greater (Regulatory Alternative IIB′), and (4) revised PM emission reduction estimates for the Guidelines. These costs and revisions were developed too late to be incorporated into the economic and benefit analyses.

[b] Values are the costs and partial benefits over those of the baseline.

[c] Incremental values are the costs and partial benefits over those of the preceding regulatory alternative, which in the case of regulatory alternative I is the baseline.

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